SCIENTIFIC AMERICAN SUPPLEMENT. No 941

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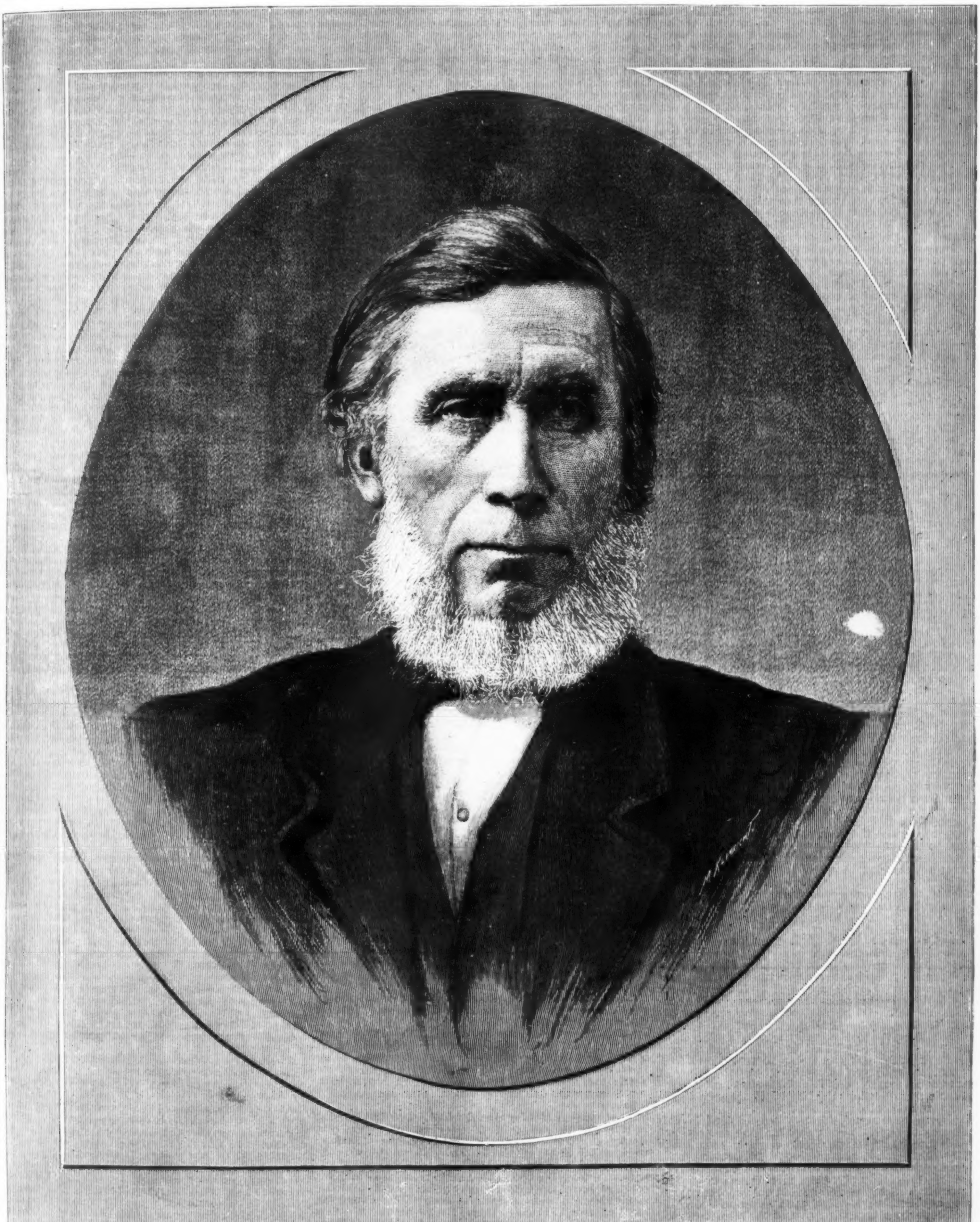
Scientific American Supplement, Vol. XXXVII. No. 941.
Scientific American, established 1845.

NEW YORK, JANUARY 13, 1894.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



JOHN TYNDALL, F.R.S.

BORN AUGUST 21, 1820. DIED DECEMBER 4, 1893.

*From the Illustrated London News.*

## JOHN TYNDALL.

By JAMES SIME.

EVERY one who takes the slightest interest in the intellectual movements of the present age was sorry to hear of the death of Professor Tyndall. No contemporary man of science was more widely known or held in higher esteem. It cannot, of course, be said that as an original investigator he ranked with the most illustrious discoverers of the nineteenth century. His contributions to knowledge cannot be compared — nor would he himself have wished to compare them—with the far-reaching results achieved by such men as Darwin, Faraday and Joule. Still, even as an investigator, he held an honored place among the scientific workers of his time, and as an expounder of the facts and laws brought to light by physical research, he displayed qualities which have rarely, if ever, been surpassed. In this respect he was equaled only by his friend Professor Huxley.

Tyndall's career, like that of most men of science, was an uneventful one, so far as external incidents were concerned. He was born in 1820, in the village of Leighlin Bridge, County Carlow. The branch of the Tyndall family to which he belonged is said to have sprung from Gloucestershire and to have settled in Ireland in the seventeenth century. His father was a trader in humble circumstances, but was a man of fine intelligence and upright character. He had so high a conception of the value of education that he contrived to keep his son at school until he was nineteen years of age. Tyndall then joined the Ordnance Survey as "Civil Assistant," and in this position, through the kindness of his chief, General George Wynne, R.E., who afterward became his intimate friend, he was allowed to make himself familiar with every department of the survey's work, both in the office and in the field. In 1844 he accepted an appointment offered to him by a Manchester firm, and during the next few years his energies were devoted to engineering in connection with railways. Meanwhile he had become profoundly interested in various branches of abstract science, and his railway work, absorbing as it must often have been, did not prevent him from carrying on studies which accorded with his inclination. In 1847, hoping to obtain more leisure for the development of his scientific powers, he accepted a post at Queenwood College, Hampshire. Here he became intimate with Dr. Frankland, instructor in chemistry; and in 1848 the two friends went together to Marburg, the university of which had been made famous among men of science by the illustrious Bunsen. At Marburg Tyndall worked strenuously, studying not only under Bunsen, but under Stegmann, Gerling and Knoblauch. Afterward he worked for some time with Professor Magnus, at Berlin, so that when he returned to England he had not only a remarkably wide knowledge of physical science, but a thorough mastery of scientific method.

In 1850, during a visit from Germany to England, Tyndall made the personal acquaintance of Faraday, and in February, 1853, he delivered his first Friday evening discourse at the Royal Institution, for which Faraday's labors had secured a splendid reputation. Faraday was so much pleased with the new lecturer that, on his proposal, Tyndall was elected to the institution's chair of natural philosophy, which had been held early in the century by Thomas Young. Tyndall had a warm admiration for the great man who had done him such good service, and his appreciation was finely expressed after Faraday's death in his well-known study of "Faraday as a Discoverer." When Faraday resigned the office of director of the laboratory of the Royal Institution, Tyndall was appointed his successor; and this position he held until 1887, when he retired. In 1876 he married Louisa, Lord Claud Hamilton's eldest daughter, who survives him. They built for themselves a pleasant home at Hind Head; and here, after his retirement, they lived during the greater part of the year, going for the summer months to their chalet on the Bel Alp, overlooking the Aletsch glacier. Professor Tyndall, as all the world knows, had an almost passionate love for the Alps. His first visit to them was paid in 1849. In 1856 he went to them with Professor Huxley, and afterward he allowed no year to pass without breathing their pure, invigorating air. The Alps interested him as a man of science, but their charm lay mainly in the power with which they appealed to his imagination. Tyndall was very far from being one of the Dryasdusts of science. A strong vein of poetry ran through all his thought and aspiration.

His researches on the properties of ice and on their relation to the theory of glaciers occupy an important place in the record of his original work. These researches were carried on partly in his laboratory, partly among the Alps, and have done much to prepare the way for the solution of a complicated set of scientific problems. In 1859 he visited Chamounix, and claimed to have determined by his measurements the winter motion of the Mer de Glace.

Even more valuable were his long-continued investigations on the relation of simple and compound gases and of vapors to radiant heat, especially radiant heat from sources at a moderate temperature. His inquiries on this question form the subject of no fewer than six papers in the "Philosophical Transactions." The conclusions at which he arrived were contested by his friend, the late Professor Magnus; but Sir George Stokes, in referring to them at the banquet given to Professor Tyndall in 1887, said that they had always seemed to him to bear the stamp of truth, and that their validity had been generally admitted. Some of the inferences from Tyndall's doctrine have an important bearing on questions relating to atmospheric temperature and climatological conditions.

For some time much interest was excited in this country by the question of "spontaneous generation." Tyndall threw himself with characteristic enthusiasm into the controversy, and succeeded in proving by a series of carefully planned experiments that the evidence for the theory of "abiogenesis" was wholly inadequate. In this research he had occasion, of course, to use only such methods as were appropriate to his special departments of inquiry, and the result afforded a striking illustration of the value of the services which may, under certain circumstances, be rendered by physics to biology.

Important, however, as these and other investigations were, it is not chiefly to them that Tyndall owes his fame. He ranked among the foremost men of his time, mainly because of his extraordinary power of awakening in the non-scientific public a vivid interest in strictly scientific results and processes. There are not, perhaps, in any language more luminous treatises of their kind than his book on "Heat, a Mode of Motion," his corresponding volume on "Sound" and the essays in his "Fragments of Science." These works are masterpieces, both of thought and style, and it is incredible, even if some of the conclusions set forth in them should become antiquated, that they will ever wholly lose the place they have won in popular scientific literature. They bring out with magnificent power, not only the methods of science, but the grandeur and impressiveness of what may be called its imaginative aspects.

Tyndall, when a boy, found much to interest him in the controversy between Protestantism and Roman Catholicism, and questions relating to religion continued to the last to play a part of immense importance in his intellectual life. No educated person whose memory goes back as far as twenty years can have forgotten the impression produced by the famous address delivered by him as president of the British Association at Belfast. Since that time the public have become so accustomed to the free expression of opinion that it would not be easy for a president of the British Association, even if his doctrines were more "advanced" than those of Professor Tyndall, to create much excitement by a statement of his views. In 1874 the conditions were different, and Tyndall's heresies necessarily gave rise to a prolonged and furious controversy. The address contained no very original ideas, but it was written in a style of remarkable grace and vigor, and at least had the merit of stimulating thought on some of the questions by which the modern world has been most deeply moved. No one would say now—as many said then—that it was the work of a thorough materialist. Some loosely expressed conceptions did seem to point in this direction, but they were not in vital accordance with the general tendencies of Tyndall's thoughts. The intimate friend of Carlyle was not likely to be a man of crudely materialistic principles.

In his later years Professor Tyndall made himself rather prominent by the vehemence with which he fought against home rule. It was natural that he should feel strongly on the subject, but the violence of his language was distasteful to many even of the most resolute opponents of Mr. Gladstone's policy. Probably it was due rather to irritation caused by ill health than to the strength of his convictions. Certainly it had a very misleading effect on those who regarded it as an expression of the essential qualities of his character. Professor Tyndall was at all times apt, perhaps, to give somewhat too dogmatic utterence to his convictions; but in his best days he had a manifest desire to be scrupulously fair in controversy, and it is well known that he often gave evidence of a finely generous temper.—*The Graphic, London.*

## FLAME.*

By Prof. ARTHUR SMITHELLS.

THE subject on which I have the honor to address you this evening is, I am aware, one of the most hackneyed among the topics that have served for popular scientific lectures. I can only hope that it has not quite lost its charm. The chemist is often twitted with having to deal with mere dead soulless things, which at the best only set themselves into angular and unpalpitating crystals. There may be a certain amount of truth in this, but in flames we surely have phenomena of some liveliness. Our flame must be fed; it has its anatomy and varied symmetry; it is vigorous, mobile and fleeting. I do not wish to make extravagant claims, but I do think that one may be excused for feeling almost as much interest in the study of flame as, for example, in the contemplation of the somewhat torpid evolutions of an amœba or the circulation of water in a sponge. To our guileless ancestors, at any rate, flame was a phenomenon of the rarest mystery; unable as they were to discriminate between the material and the immaterial, unable to track the solid or liquid fuel to its gaseous end, this radiant nothingness called flame became to them one of the primary inscrutable, irresolvable things of nature—an all-devouring element, often of peculiarly divine significance.

The essential nature of flame appears to have been discovered at the beginning of the seventeenth century by the Belgian Van Helmont. This remarkable man is well known to chemists as one of the acutest and least superstitious of the whole band of alchemists. He was somewhat speculative in the domain of physiology, but in chemistry Van Helmont made discoveries of fundamental importance. From our immediate point of view, one of the most important things he did was to sweep away the mystery that had so long attached to the gaseous state of matter. In so far as he distinguished between different gases obtained from different sources he may be said to have been the first to bring aeriform matter within the range of substantial things that might be submitted to experimental investigation. It was in consequence of this that he was led to the discovery of the nature of flame. I will quote the important passage from his writings.

"But the flame itself, which is nothing but a kindled smoke, being inclosed in a glass in the very instant perisheth into nothing.

"The flame indeed is the kindled and enlightened smoke of a fat exhalation; be it so; but as the flame is such and true fire it is not another matter, being kindled and not yet kindled, neither doth it differ from itself; but that light being united in its center, hath come upon a fat exhalation which is the same as to be inflamed.

"Let two candles be placed which have first burned awhile, one indeed being lower than the other by a span; but let the other be of a little crooked situation; then let the flame of the lower candle be blown out; whose smoke, as soon as it shall touch the flame of the upper candle, behold the ascending smoke is enlightened, is burnt up into a smoky or sooty gas, and the flame descendeth by the smoke even unto the smoking candle. Surely there is there, the producing of a new being, to wit, of fire, of a flame, or of a connexed light; yet there is not a procreation of some new matter or substance.

"For the fire is a positive artificial death but not a privative one, being more than an accident and less than a substance."

We can best understand the meaning of this somewhat oracular statement by repeating Van Helmont's experiment. We take a bundle of lighted tapers so as to get a large flame, we hold over "in a little crooked situation" another lighted taper, and now blow out the lower flame. We note the ascending column of smoke, and observe that when it touches the upper flame it ignites, and the flame descends several inches through the smoke to the bundle of tapers. Flame, therefore, says Van Helmont, is burning smoke; it is not a new substance nor a mere chance occurrence, but the incandescence of a vapor or smoke that already existed.

Van Helmont only recognized in a vague way the important part played by the atmosphere in the phenomenon. This was realized much more perfectly soon afterward by Hooke, who speaks of "that transient shining body which we call flame" as "nothing but a mixture of air and volatile sulphureous parts of dissoluble or combustible bodies which are acting upon each other while they ascend," an action so violent, he says, that "it imparts such a motion or pulse to the diaphanous parts of the air" as was requisite to produce light.

Without entering further into early historical details, I may say that it was only toward the end of last century that the essential chemistry of the phenomenon was fully expounded by the great Lavoisier. He showed that as Hooke had surmised, flame is the region in which combination attended by the evolution of light takes place between the components of a gaseous substance and the oxygen of the air.

The next step in the history of our knowledge of flame brings us to the memorable researches of Humphry Davy, whose name more than that of any other man is associated with this subject. Of Davy's work I shall have more to say presently; but at this moment I will only make one allusion to it, an allusion which will provide us with a proper starting point this evening. It is interesting to note that Davy's discoveries concerning flame were the consequence and not the cause of the discovery of the miner's safety lamp. In this case practical application preceded purely scientific discovery.

I need not describe the safety lamp to you in Nottingham, where it has recently received such important improvements at the hands of Prof. Clowes. When the lamp is placed in an explosive mixture, you know what happens—the explosive mixture burns with a quiet flame within the lamp, but the flame cannot pass through the wire gauze to ignite the mixture outside the lamp. I can demonstrate this by means of this large gas burner, which is primarily a Bunsen burner, that is a burner which by means of holes at the base of the tubes draws in sufficient air to enable the gas to burn with a practically non-luminous flame. If I turn on the gas and apply a light to the top of the burner, you observe that I get a flash and a small explosion within the tube, but no continuous flame. The fact is that the mixture of gas and air within the tube is highly explosive. Placing a gauze cap over the burner and applying a light, I now get a steady flame. The explosive mixture made in the tube passes through the gauze and is inflamed, or, if you like, exploded; but the explosion cannot pass through the gauze, because the metallic wires withdraw the heat so rapidly that the mixture below it never reaches the temperature of ignition. Above the gauze we have the continuous flame.

"These results are best explained," says Davy, "by considering the nature of the flame of combustible bodies, which in all cases must be considered as the combination of an *explosive mixture* of inflammable gas or vapor and air; for it cannot be regarded as a mere combustion at the surface of contact of the inflammable matter."

Davy, then, regarded flame as being essentially the same as explosion; it was, in fact, a kind of tethered explosion.

Since Davy's time we have learned much about the nature of gaseous explosions, and we now know that such explosions, when fully developed, proceed with enormous rapidity and are of great violence, incapable of arrest by such simple means as we have just used. Still there is not much to correct in what I have said. I think I cannot do better than show you the transition of flame into explosion by an experiment which was first shown by Prof. Dixon in the lecture which he gave at the meeting of the British Association in Manchester in 1887.

The apparatus before you consists simply of a Bunsen burner surmounted by a long glass tube. If I turn the gas on and light it, I obtain at the top of the glass tube a steady flame. The mixture ascending the tube can scarcely be called explosive at present, but if I alter the proportions of gas and air suitably it becomes distinctly explosive. Observe what happens when this is the case. The flame can no longer keep at the top of the glass tube; it passes within it, and descends with uniform velocity till at a certain point it flickers and then shoots down almost instantaneously to the bottom. This sequence of events is exhibited in all cases when flame develops into explosion. We are concerned only with the first phase, viz., that of comparatively slow inflammation, and a flame, we may say, is a gaseous explosion brought to anchor in the period of incubation.

There is one other point connected with explosion that we must note on account of its important bearing on the chemistry of flame. When we are dealing with explosive mixtures of gas and air, we find practically that the composition of the mixture may vary considerably and still retain its explosive properties. There is, of course, a certain mixture which presents the greatest explosive power; a further quantity of the combustible gas or of the air will diminish the explosibility, but not entirely destroy it till a large excess is used. With hydrogen, for example, two and a half times the volume of air (which contains exactly the oxygen requisite to combine with the hydrogen and produce water) is the right quantity for the maximum explosive effect, but we still get explosion when we have much more than two and a half times as much air as hydrogen, or when, on the other hand, we have much less. In one case there will be oxygen left uncombined, in the other case hydrogen. I dwell upon this in order

* An evening discourse to the British Association at the Nottingham meeting, September 15, 1893. From *Nature*.

that we may be prepared to find the same thing in flames, in order that we may not be surprised to find combustion taking place in mixtures where either gas or air is in excess of the quantity actually required for the purpose of chemical combination. Bearing this in mind, let us revert to the experiment that I have just shown. It consists, you remember, in mixing air with gas before burning it, to such an extent that the flame strikes down the tube. On a close examination we find that this is not quite a correct statement, for when I regulate the air with nicety you see that it is only part of the flame that strikes down the tube. There remains all the while at the top of the tube another part of the flame which is not mobile. With a little care I can adjust the proportion of air and gas so that the part of the flame which is mobile shall move up and down the tube like a piston. All the while you see the pale, steady flame at the top of the tube. When in this critical condition a little more air determines descent of the movable part of the flame, a little less sends it to the top.

Let us now turn to the explanation of this phenomenon. It is clear, in the first place, that coal gas and air form an explosive mixture long before there is enough air to burn all the gas. For it is only part of the flame that descends the tube, and there is enough gas passing through this part to form a second flame as soon as it reaches the outside air at the top of the tube. There is, as a matter of fact, only about two-thirds as much air entering the tube at the bottom as would be necessary to burn the whole quantity of gas. We see, in the next place, that the explosibility varies greatly according to the proportions of gas and air. For what is the cause of the descending flame? It is simply that we have an explosive mixture in process of inflammation. The inflammation is tending downward; opposed to it is the movement of the explosive mixture upward. If the upward movement of the unburned mixture is more rapid than the downward tendency of the inflammation, the flame cannot descend. We can only make it descend by making the downward tendency greater. This we do by adding more air, and making the mixture more explosive. We see that we can balance these two opposite velocities with the greatest nicety by a careful adjustment of the proportions of the explosive mixture.

In order to ascertain what proportion of gas is being burned in this movable flame, and what is the chemical character of the products there formed, it is necessary to keep the two parts of the flame separate, and to take out some of the gases from the intervening space.

This is very easily done. The flame descends, we have seen, because its rate of inflammation is greater than the rate of ascent of the combustible mixture. If now we can make this rate of ascent more rapid at one part of the tube than it is anywhere else, we may expect to stop the descent of the flame at that point and keep it there. We can do this simply by choking the passage; for just as a river must flow rapidly where its banks are close, so must the stream of gas rush more rapidly where the tube is choked than either below or above, where there is a wide passage. If, then, I replace the plain glass tube by one that has a constriction in one part, and if I cause the inner cone of the flame to descend as before, it stops, as you see, at the constriction, and will remain there any length of time.

Its rate of descent is greater than the rate of ascent of the gas where the tube is wide, but not so great as that where it is narrowed by the constriction. We have now got the two cones of flame widely separated. In this state of things we can, if we choose, draw off the gases from the space between the two cones by putting in a bent glass tube and aspirating. We could

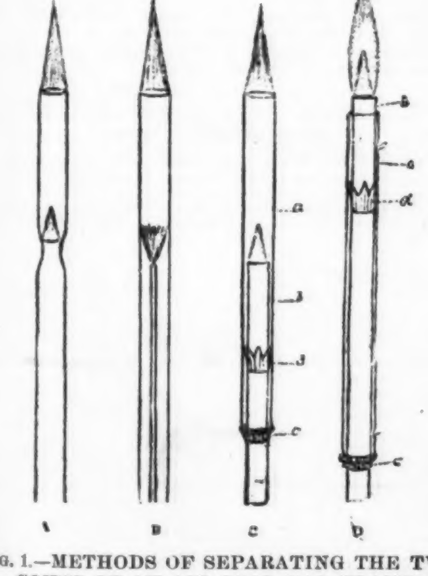


FIG. 1.—METHODS OF SEPARATING THE TWO CONES OF AN AIR COAL-GAS FLAME.

then analyze these gases and see what has happened in the first cone. (Fig. 1, A.)

I will now show you another method in which the two cones can be separated. It is based on the same principles as the one just used. I have here a two-coned flame burning at the top of a glass tube. I shall let the air supply be liberal, but not quite sufficient to cause the descent of the inner cone. The rate of ascent of the gas is now just a trifle greater than the rate of descent of the flame. If now I retard the rate of ascent of the gas, the balance will be disturbed and the inner cone will descend. I can easily do this by laying an obstacle *along* the stream of gas, for at the end of it there will be no more current than you would find over the stern of a boat anchored in midstream. I take this obstacle, then, in the form of a glass rod fixed centrally along the current of gas; I push it up until it touches the tip of the inner cone, and then pull it down again. You observe what has happened. The cone has followed the rod into the tube, and remains attached to it.

You will notice, too, that the cone is inverted. That is easily understood. It is only at the tip of the rod that the current is slowed down; there only is the rate of ascent of the stream less than the rate of inflammation. The tendency in every other part of the stream is for the cone to go to the top; hence the inversion. (Fig. 1, B.)

We can get a still more convenient apparatus by a modification of the first method. Instead of choking the bore of the single tube by a constriction, we may use two tubes of different diameter, one sliding within the other. This apparatus is shown in Fig. 1, C; *a* is the wider tube, *b* the narrower one. The two tubes are connected by an india rubber collar, *c*, and kept steady by the brass guide, *d*. The outer tube can be slid up and down the inner one as desired. If we place this apparatus over a Bunsen burner and turn on the gas, we shall have a tolerably rapid upward current in the inner tube, but as soon as the gas emerges into the wider one, its velocity will of course diminish. The consequence is that if we now light the gas and gradually increase the air supply, the inner cone will descend until it reaches the orifice of the narrower tube; but at that point, meeting with the rapid stream, its progress is arrested, and it remains perched on the end of the tube. By sliding the tubes we can thus separate the cones any desired distance, or we can bring their orifices level and restore the original flame. Lastly, we can restore the original flame. Lastly, we can reverse the experiment, for we can begin with a two-coned flame burning at the protruding end of the narrower tube, and by sliding up the wider tube detach the outer cone and carry it upward. (Fig. 1, D.)

Having now learned the relation of flame to explosion, having discovered that flames have separable regions of combustion, and having armed ourselves with an appliance for dissecting the flame, we may proceed to discuss the main question.

I do not intend this evening to enter seriously into chemical details, but there are one or two simple points to which I must draw your attention. Flame, we see, is a region in which chemical changes are taking place with the evolution of light. It is to be expected, therefore, that the character of a flame, its structure and appearance, will vary according to the chemical changes that give it birth; and we should naturally anticipate that the more complex the chemical changes, the more complex would be the flame. The kind of complexity to which I refer is illustrated by the diagram.

| Name. | Composition. | Products. | |
|---|---|---|---|
| | | Partial Combustion. | Complete Combustion. |
| Hydrogen. | | water. | water. |
| Carbon monoxide. | carbon and oxygen. | carbon dioxide. | carbon dioxide. |
| Carbon. | | carbon monoxide. | carbon dioxide. |
| Cyanogen. | carbon and nitrogen. | carbon monoxide and nitrogen. | carbon dioxide and nitrogen. |
| Hydrogen sulphide. | hydrogen and sulphur. | (?) | water and sulphur dioxide. |
| Hydrocarbons. | hydrogen and carbon. | carbon monoxide, carbon dioxide, hydrogen and water. | carbon dioxide and water. |

In the first column are the names of five combustibles; their chemical composition is stated in the second column. All these substances in burning combine with the oxygen of the air. The case of hydrogen is the simplest. This gas, when it burns, unites with half its volume of oxygen, and forms steam. The process is incapable of any complication. We might predict, therefore, a very simple structure for a hydrogen flame. The same is true for the next gas, carbon monoxide, which, although a compound, unites at once with its full supply of oxygen and burns, forming carbon dioxide.

The third combustible, carbon, presents a new feature. In burning it can combine with oxygen in two stages, forming in the first instance carbon monoxide, which, as we have just seen, can itself combine with more oxygen to form carbon dioxide. We cannot vaporize carbon and use it as a gas; so that we shall not actually deal with this example. But the next combustible on the list, cyanogen, will serve almost as well, for it is a compound of carbon with nitrogen, and nitrogen is, under ordinary circumstances, practically incombustible. To use cyanogen is thus much the same as to use carbon vapor. We may expect some complexity in the cyanogen flame, in consequence of the fact that carbon can burn in two steps. The next combustible, hydrogen sulphide, presents a further degree of complexity. It is composed of two elements, each of which is combustible on its own account. Lastly, we come to the great class of hydrocarbons, which includes all ordinary combustibles, oil, tallow, wax, petroleum, and coal gas. The carbon and hydrogen are both separately combustible elements, and one of them—carbon—is, as we have seen, combustible in two steps.

We will now consider the problem in its simplest aspect. For this purpose I choose the gas carbon monoxide. I should choose hydrogen were it not for the fact that its flame is almost invisible. We will allow a stream of carbon monoxide to issue from the circular orifice of this glass tube. Lighting the gas, we get a blue flame. On examining this flame closely, we perceive that it is simply a hollow, conical sheath of pretty uniform character. I need scarcely demonstrate that it is hollow, but I may do so in a moment by using Prof. Thorpe's simple device of thrusting a match head into the center of the flame—a pin passing through the stick of the match, and its ends resting on the tube. The match head is now thrust well up inside the flame, and you observe that it remains there sufficiently long without burning to make it quite clear that there is no combustion within the cone. The conical form of the flame is easily explained. As the stream of gas issues from the tube the outside portions become mixed with the air and burn. The inner layers must successively travel further upward, like the successive tubes of a telescope, before they can get enough air to burn, and in this way we arrive at the conical form.

There still remains one thing to account for, and that is the luminosity and color of the flame. The questions here involved are perhaps the most interesting of all, but they are complicated, and I will not say more than a few words about them. The most obvious answer to the question: "Why is the flame luminous?" is to say that the heat developed during the chemical combination raises the product of combustion to a temperature at which it glows—a "blue heat" in the present case. Now if we put a thermometric instrument into the carbonic oxide flame, it does not register at any point as high a temperature as 1,500° C., but if we take carbon dioxide and heat it in a tube by external heating to 1,500° C., we get no signs of luminosity whatever. On these grounds several eminent investigators have been led to abandon the simple explanation above given, and to say that the luminosity of a carbon monoxide flame must depend not on the heat of chemical combination, but on something in the nature of electrical discharges between the combining substances, which discharges produce the disturbances of the ether

FIG. 2.—TYPICAL FLAMES.

*a*, carbon monoxide, single coned; *b*, cyanogen, two coned; *c*, small coal-gas flame.

perceptible as light. This view seems to be fraught with a fundamental error. The temperature registered by any instrument introduced into a flame is an *average* temperature, uncorrected for losses by conduction. It is not the temperature of the newly-formed gas, but of the mixture of that and the unburned gases. If we had a very small instrument which we could apply to the particles of newly-formed gas, we should undoubtedly find them at a very much higher temperature than any indicated by the ordinary thermometric apparatus, and it is not unlikely that the temperature would be several thousand degrees, approximating indeed to the temperature at which we arrive by calculation from the heat of combustion of the gas and the heat capacity of the product. We cannot say that the flame is luminous from some other cause than simple hotness, for we have no means of seeing whether carbonic acid glows when raised by external heating to a temperature of several thousand degrees.

At the same time one cannot help remarking on the similarity between such a flame as that of carbon monoxide and the appearance presented by an attenuated gas when submitted to the electrical discharge in a Geissler tube. I have here such a tube, containing carbon dioxide, and I have placed a mask over it, so that we see a long triangular piece of it. When I pass the discharge you see it lights up and presents an appearance strikingly like that of our conical flame of carbon monoxide. There may be a close relationship between the phenomena, but we cannot affirm it yet. No doubt we shall soon learn a good deal more about both phenomena.

We have now done with the simplest kind of flame. We see that it consists of a single conical sheath of combustion, at every point of which the same chemical change is taking place, and every point of which in consequence has the same appearance.

We pass to the cyanogen flame. This flame is one of remarkable beauty; it consists, as you see, of two distinct parts: one a rose or peach blossom colored cone, surrounded by a paler cone, which is bright blue where it is near the inner cone, and shading off to a kind of greenish gray. What is the cause of this double structure? It might be that part of the gas is burning round the orifice, the rest further out in the second cone; but a similarity of the chemical processes in the two parts of the flame is here rendered improbable by the difference in color. The only satisfactory way of answering the question is to separate the cones, and analyze the gases in the intervening space. This we can easily do in the cone-separating apparatus.

I now form the flame at the top of our cone-separating apparatus, and supply a certain amount of air along with the cyanogen. You observe the rose-colored cone contracts somewhat. The gas burning there now gets its air supply easily, and has not to wander outward. If I still further increase the air supply, and make the ascending mixture explosive, you see the inner cone begins to descend into the tube, and passes down until its progress is checked at the narrow tube, where the uprush of gas is more rapid. We have now got the cyanogen flame dissected, and by taking out a sample of the gases from this intercoal space and analyzing, we shall find what chemical change has taken place in the inner rose-colored cone. The analysis shows that what takes place is the combustion of the carbon of the cyanogen to form carbon monoxide almost exclusively; the carbon monoxide then ascends, and when it meets with more oxygen in the outer air, burns in a second cone to form carbon dioxide.

Reverting then to the flame of the pure unmixed gas burning at the top of a tube, we see that the gas and air will interpenetrate. When there is just enough oxygen to burn the gas to carbon monoxide, we get the rose-colored cone, and outside it, where this carbon monoxide gets more air, we have a second cone. The two-coned structure corresponds then to two chemical stages of combustion.

Now we might go further and anticipate that if we supplied a very large quantity of air to the cyanogen, as in a blowpipe, the two-coned structure would disappear, for the carbon should be burnt up at once to the ultimate product, carbon dioxide. We can easily try this. I will separate the two cones again in our ap-

paratus, and increase the air supply still further. When I do so you observe that the second cone gradually fades away, and now the whole of the combustion is taking place at the end of the inner tube. Though this is so, the flame is not quite a simple cone. It is, as you see, surrounded by a greenish halo. This halo is due, I believe, as Prof. Dixon has suggested, to the fact that the nitrogen of the cyanogen is not, strictly speaking, incombustible. This has been proved by Mr. Crookes in his beautiful air flame, and besides, the greenish halo is frequently noticeable in cases of combustion where oxides of nitrogen are present.

*(To be continued.)*

## IMPROVEMENT OF POTOMAC FLATS, WASHINGTON.

THE improvement of the river front of the city of Washington, D. C., popularly known as the Potomac Flats Improvement, was intended to accomplish two objects: First, to improve navigation, for which annually the government has for years been expending a large sum of money; and second, to fill up a large area of marsh land, which was overgrown with a dense growth of grass. The marshes were what are known as the flats. There were many acres of these marshes bordering on the river bank, which were exposed at low and covered at high tide. One of the largest sewers of the city discharged its contents on these flats, and being exposed daily to the rays of the sun, when the tide was low, rendered a large section of the city almost uninhabitable. The executive mansion itself was only about 2,500 feet from the flats, which became such a public nuisance that what had been one of the most desirable sections of the city became the most undesirable for residence.

In 1881 the Senate appointed a committee to investigate the case. The direct result of this investigation was an appropriation by Congress of $400,000 to begin the work of improvement. Since then successive appropriations have been made at intervals of two years, and the amount expended up to the present time has been $1,624,798. The estimated cost of the entire work was $2,716,365, and notwithstanding the unbusinesslike methods of Congress in appropriating insufficient sums to prosecute the work vigorously, and the damage it has consequently sustained from freshets, the work has been brought to that advanced state that it could yet be completed within the estimates. Considering the magnitude of the work, and the fact that the estimates were regarded as low, this is justly regarded as a satisfactory exhibit.

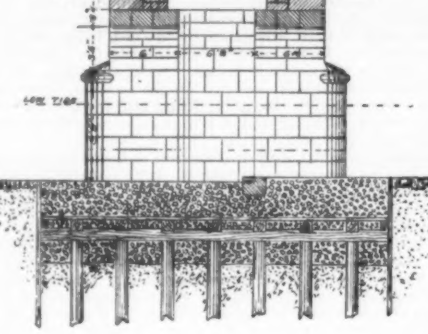
The total area of land reclaimed is in round numbers 621 acres. The material with which the fill was made was taken from the river channels, and thus accomplished the double purpose of improving the navigation and reclamation of the flats.

The question of the disposal of dredgings taken from rivers to improve navigation is becoming a serious one. The old dumping grounds are rapidly becoming filled up, and even when others are found at a long distance from the place to be improved, there is great danger of the material being swept back into some other channel, and thus create a new obstruction where none before existed. In many places satisfactory dumping grounds cannot be found at all; in others the vested rights of adjacent owners of land forbid it.

The work of taking the material from the bed of the river was done in different ways. At first the channels were dredged in the ordinary way, with clam shell and dipper dredges, the material being loaded into scows and then conveyed to a basin located at a convenient point, from which it was again taken up and loaded on railroad cars, which conveyed it to the place of deposit on the flats. The tracks in this case were carried on trestle work, made by driving piles in the flats on the area to be filled, and capping them with heavy timbers. The tracks were raised to a sufficient height to cause the material, when dropped from the cars, to fall with such force that it is spread out laterally to a distance of several hundred feet, and when it did not spread itself, a pump was used to level it down. This method of deposit had several disadvantages. It was expensive. The amount of material that could be dropped at any particular point depended altogether on its character. Soft mud spread out well, but sandy or gravelly stuff did not. The material had to be lifted through a considerable vertical height no less than three times—a wasteful expenditure of energy.

Another method was to dredge the material from the river by means of a centrifugal pump, and force it ashore through pipes carried on scows or pontoons. This work we show in the cut on opposite page, the material being delivered under pressure to a considerable distance. The boat shown in the illustration is 110 feet long; beam of boat, 50 feet. The rotary centrifugal pump is 8 feet in diameter, and 21 inches discharge. Two engines are required to run the pump, each 22 inch cylinder and 24 inch stroke, making 150 revolutions per minute; steam 90 pounds to the inch. Two locomotive boilers, each 60 inch diameter, 25 feet long. Two engines to run the plows, each 10 × 20, running 120 revolutions per minute, discharging through 4,200 feet in length of 20 inch discharge pipe.

This pump has a capacity of 10 cubic yards per minute in stiff blue clay and a greater capacity in other material. Three of these hydraulic dredges were put on the work at various times. The material dredged in this way when deposited on the flats spread itself out in low conical heaps and gave good grades. When the material was very soft, it spread out quite flat. This




VERTICAL SECTION ON "C D." GATE REMOVED.

RESERVOIR OUTLET—VERTICAL SECTION.

method of dredging proved economical and advantageous, but it was necessary to prepare the place of deposit by constructing embankments around it. As these embankments became in fact a part of the fill and were cheaply constructed, the hydraulic method of dredging was very satisfactory. The centrifugal pump dredge was known as the McNee dredge, and has been used on other important work, giving good satisfaction. As it deepens the channel and deposits the material at any distance required up to one mile at one operation, it is by far the cheapest method that has been employed. Many of these dredges are now in use in different sections of the country. They are owned and operated by the Hydraulic Dredging and Improvement Company, of Philadelphia, Pa.

Another method was introduced at a later stage of the work, and consisted in dredging the material into scows and conveying it to a pump operated on the pulsometer principle. This pump was located near the margin of the flats, and set in a hole in the bed of the river. The dredged material was dumped into this hole, from which it was sucked up by the pump and forced into a chute which carried it out to the place of deposit. The mode of operating the pump was to fill a large cylindrical tank with steam, the pressure from which drove out any material in the tank, and raised it to the top of the chute into which it discharged. By means of a shower bath the steam was then condensed, which closed a valve in the discharge pipe and opened one in the suction. The latter being buried in the dredgings which were deposited over the end of it, and a vacuum being produced by the condensation of the steam in the tank, an inrush of mud or mud and water took place, soon filling the tank. It was then forced out as before. This method of dredging necessitated the construction of long chutes, and as the material had to run down by gravity, the end into which the pump discharged had to be high.

The filling of the flats converted the old Washington channel into an arm of the river, closed at the upper end, into which some sewage would necessarily go. To purify this, a tidal reservoir of about 110 acres was constructed just above Long Bridge, from which about 250,000,000 gallons of water would be discharged daily into the head of the Washington channel.

The water is taken into the reservoir from the Virginia channel on the flood tide and discharged into the Washington channel on the ebb. To control this operation it was necessary to construct, near Long Bridge, the reservoir outlet, which is provided with gates that work automatically, closing on the flood and opening on the ebb tide. A set of inlet gates, to work on the same principle, may also be needed.

The reservoir outlet is a masonry structure, consisting of a breast wall perforated by six arched openings, with two wing walls on the upstream and two on the downstream side. Each opening is 10 feet wide and 18 feet to the crown of the arch, the bottom being 6 feet below mean low tide. The discharge area is therefore 360 square feet at low tide and 540 square feet at ordinary high tide. The gates, when closed, rest against miters at the bottom and top, and when open set back into a recess in the side walls. They are built of wood, and pivoted at the heel, so as to make the friction the least possible. No mechanism is needed to start the gates closing from their positions in the recess of the masonry; the action of the water does this automatically as soon as the tide begins to run up stream.

Considerable difficulty was experienced in securing a foundation for this structure. The bed of the river here consists of very soft mud to a depth of fifty to sixty feet, then layers of sand of varying thickness are encountered, with layers of mud between. At a depth of seventy-two to seventy-five feet a compact layer of gravel is found. As any unequal settlement would disarrange the gates, it was deemed necessary to drive piles to the latter depth. These were capped by two sets of grillage timbers, and the spaces between them, and for two feet below the heads of the piles, were filled in with concrete.

The total amount of material thus far dredged and deposited on the flats is in round numbers about 8,642,000 cubic yards. The price paid for dredging, exclusive of embankments, has varied from 12·37 cents to 21·2 cents per cubic yard, but besides the dredging there has been a large amount of stone used as a footing for the embankments, and foundations for protecting walls. The total cost of the entire work thus far, including everything, has been $1,624,798. The value of the land reclaimed, in its present condition, is estimated at not less than about $3,000,000, so that viewed as a commercial enterprise, it has been a profitable undertaking for the government.

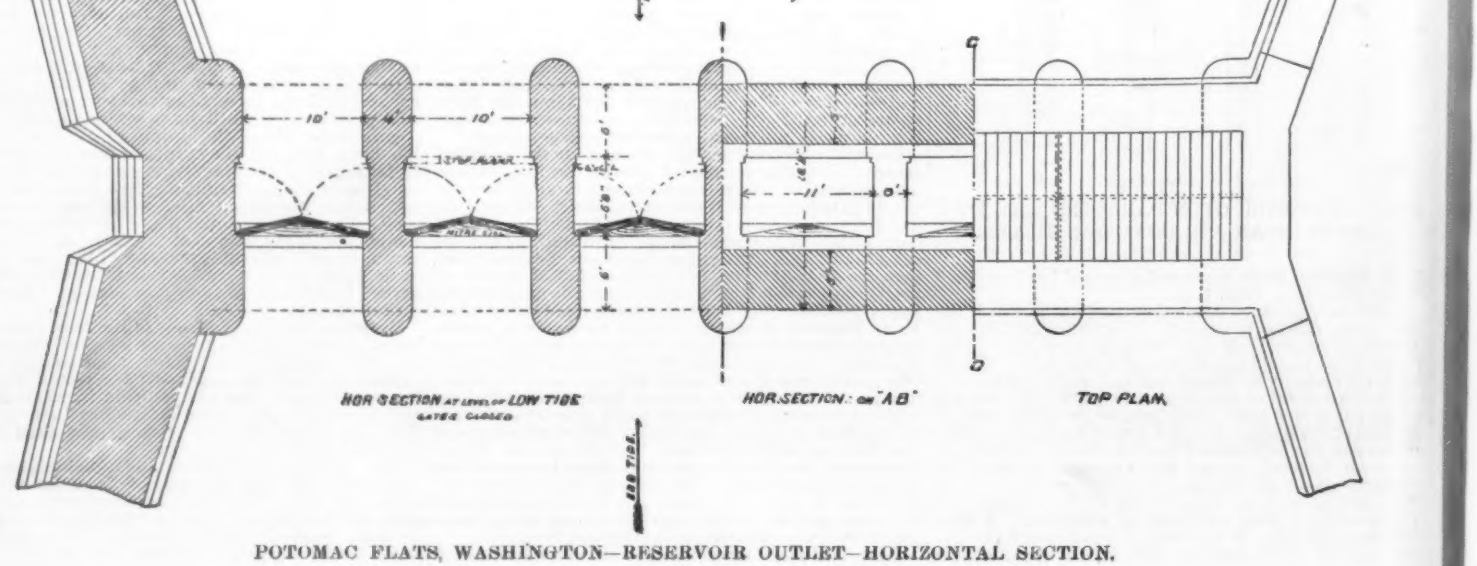
One of the views shows the condition of the flats at low tide, as given by a photograph taken from the top of the unfinished Washington monument in October, 1883, when the monument had reached a height of 384 feet. Another view represents the improvement as it appears to-day, and was taken from the top of the present Washington monument. The diagram, drawn to a scale, gives the relative size and positions of different parts of the work, all of which has been done under the direction of Col. Peter C. Hains, U. S. A., in charge of various public works in the immediate vicinity of Washington, and to whom we are indebted for the details given.

From the Capitol to the Virginia channel is now one large park, marred only by the unsightly tracks of the Baltimore and Potomac Railroad. Embraced in this area are the Botanical Gardens, Medical Museum, Smithsonian, Agricultural Department, Bureau of Engraving and Printing, and the Washington monument. This park is a favorite drive for the thousands of visitors to the capital, and the grounds of the White House border it on the northwest.

## RECLAMATION OF THE POTOMAC FLATS, WASHINGTON, D. C.*

THE Potomac River, from Little Falls to its mouth, is a tidal stream, the tidal range at Washington being 3

* Abstract of a paper by Peter C. Hains, Lieutenant-Colonel, Corps of Engineers, U. S. A., M. Am. Soc. C.E.; reprinted from the Bulletin of the Society.



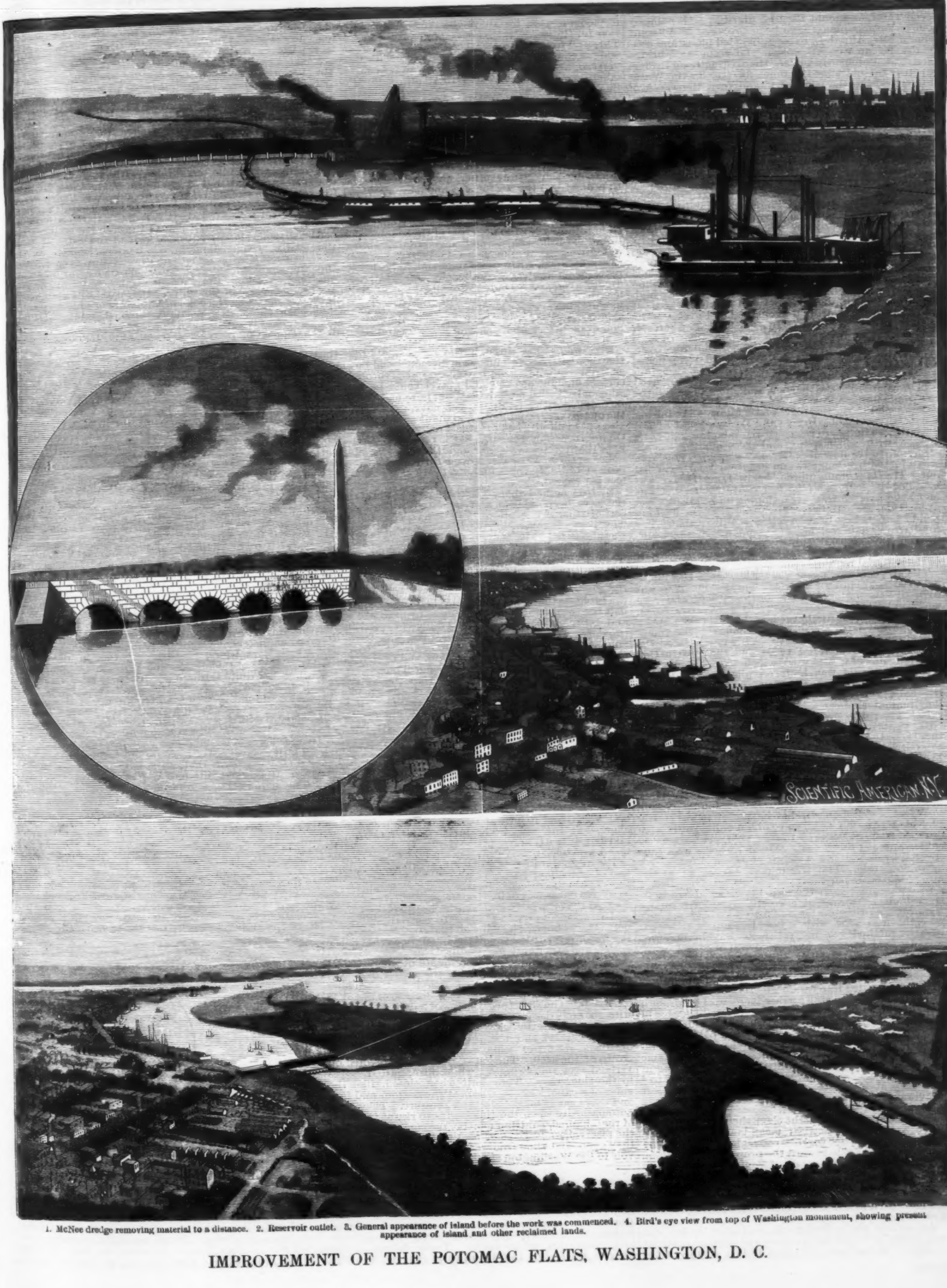

POTOMAC FLATS, WASHINGTON—RESERVOIR OUTLET—HORIZONTAL SECTION.

feet and at its mouth 1½ feet. There is a good channel all the way to Washington, which is rather shoal in a few places and is bordered on the sides with large areas of flats or marshes. From the earliest times there have been always two channels in the harbor of Washington, and sometimes three. The Virginia channel is the widest and deepest, passing between the Virginia shore and Analostan Island. In 1806 this was closed by a dam between the island and the shore and was forced over to the Georgetown side, forming the Georgetown channel. The island thus became a training dike, but was not long enough. The shoal place remained shoal, and a large area of flats was created below the island.

The second or "swash" channel branched off from the Washington channel opposite Sixth Street, pursued a southwest course through the middle of what is now the causeway of Long Bridge, and joined the Virginia channel below Easby's Point. This had a depth of about 6 feet at low tide, but is now almost obliterated. The third or Washington channel branched from the main channel opposite the mouth of the eastern branch, followed along the Washington shore to Easby's Point, and there joined the Virginia channel. This at one time had a depth of nearly 3 feet, but is now almost entirely filled up.

The same causes that produced the shoaling of the channels also formed the Potomac flats at Easby's Point. At their upper limit the river is about 900 feet wide, while immediately below it is about 5,000 to 6,000 feet. This sudden expansion in width causes a deposit of silt in times of freshets, filling the channel to some extent, but filling still more the eddies and dead water behind Easby's Point.

The drainage area of the river is about 20,000 square miles, and freshets reach to a height of 40 to 45




1. McNee dredge removing material to a distance. 2. Reservoir outlet. 3. General appearance of island before the work was commenced. 4. Bird's eye view from top of Washington monument, showing present appearance of island and other reclaimed lands.

IMPROVEMENT OF THE POTOMAC FLATS, WASHINGTON, D. C.

feet at the falls, discharging the enormous quantity of about 380,000 cubic feet per second. The great quantities of silt brought down by freshets are deposited in the eddies and behind projecting points, and as the water subsides, quantities are deposited in the channels. This filling up requires frequent dredging of the channels, to maintain the requisite depth for commerce. The Potomac flats have continued to increase until they have become a nuisance, which has been aggravated by the discharge of a large amount of sewage upon them, the stench from which is at times almost intolerable. A change in the disposal of the sewage would only lessen but not cure the evil. The question was, Should the flats be filled up above the level of overflow, or dug out so as to form a large area of deep water, or should they be diked in and pumped out? Various plans have been proposed at different times. Mr. Alfred L. Rives submitted plans and estimates for an iron suspension and stone arch bridge across the Potomac to replace the existing Long Bridge; to open the old swash channel, fill out on the Washington side to the edge of it, and turn the waters of the Virginia channel into the new one by means of breakwater, etc.; but the plan was incomplete, and would only have transferred the difficulty to another point of the river.

A plan by the board of survey contemplated filling out on the Washington side along the whole city front to the Virginia channel, the construction of bulkheads and docks, and excavation to 23 feet depth at mean low tide. Over 1,000 acres of land were to be reclaimed.

In 1879 Major Twining, Engineer Commissioner of the District of Columbia, proposed to advance the city front, but not so far. He introduced an entirely new feature—the use of flushing ponds or lakes by which the Washington channel was to be made a tidal arm of the river, closed at the upper end and from all connections with the river. The reservoir thus formed was to be arranged with inlet and outlet gates working automatically with the tides, taking water in at high tide from the Virginia channel and discharging it at the head of the Washington channel on the ebb. The plan reclaimed 528 acres. In 1882 Mr. S. T. Abert, M. Am. Soc. C. E., proposed to fill the flats only to a level of 6 feet above low tide, and protect them from overflow by an embankment. In 1882 a board of engineers, consisting of Lieutenant-Colonels Gillmore, Craighill, and Comstock, of the Corps of Engineers, submitted a plan combining the harbor and shore lines and the low grade filling and surrounding embankment of Mr. Abert's plan, with the high grade filling and sluicing ponds between Long Bridge and Easby's Point of Mr. Twining. The board regarded the rebuilding of Long Bridge, with wider spans, and piers offering less obstruction to the flow of water, as essential. This plan was adopted by Congress and has been nearly carried out. The low grade filling below Long Bridge was modified in 1887 to a fill 3 feet above the freshet line along the axis of this area, sloping off to about 6 feet at low tide, the margin on either side. For the flushing ponds a single lake or reservoir was substituted. The total area of flats reclaimed is about 625 acres, requiring about 12,000,000 cubic yards of material. The law contemplated the taking of the greater part of the material required from the bed of the river.

The first contract made was for dredging the channel to 20 feet depth and 400 feet width. The plan was to dredge the material in the ordinary way and convey it in bottom dumping scows to a receiving basin, where it was to be discharged, and again taken up by a dredge and deposited in cars and hauled to the dumping ground by a locomotive. This necessitated the handling of the material twice, and the construction of a long line of trestle work which soon became useless. The trestle was built on piles mostly 60 to 70 feet long, cut off at about 10 feet above the surface of the flats, and capped with timbers. On these caps longitudinal timbers were laid, and on the latter the rails. The cars were double side dumpers, holding 10 cubic yards each, and were hauled out in trains of 10 cars each, the contents being all dumped at one time. For putting the material on the flats above Long Bridge, 13,000 linear feet of trestle was constructed, and there were deposited on this section about 863,000 cubic yards, giving only about 66 cubic yards per linear foot of track built. To facilitate loading, the tracks at the receiving basin were only 4 feet above low tide, rising by a grade to 12 feet. Below Long Bridge the single line was mostly 12 feet above the flats, and 557,000 cubic yards were dumped from 7,400 feet of trestle; this gave about 75 cubic yards per linear foot. About 120 acres were thus covered by deposits to a depth of about 6 feet above mean low tide. The trestle cost $80,000, or at the rate of two cents per cubic yard of material handled.

After dumping from the cars, the material had to be leveled off by means of a Worthington force pump. By means of this, water was forced through a 4 inch wrought iron pipe with a hose and nozzle attached, but the method was not satisfactory. The material was dredged from an average depth of 18 feet below mean tide, and raised by the first operation 8 feet above tide, or 26 feet in all. It was then towed to the receiving basin, dropped, again picked up and raised 28 feet and loaded into cars. The rise of the grade of the tracks made a still further increase of 6 feet, or a total lift of 60 feet; whereas, the average difference in level between the material in the river and on the flats was only about 21 feet. The price paid was 21·2 cents per cubic yard (scow measurement), which included all the profits to the contractor. At the same time the construction of embankments was begun along the marg'n. These were formed in water 2 to 4 feet deep at low tide. The material was mostly soft alluvium, with some sand. The embankments were made as follows:

An ordinary light draught clam shell dredge would make a cut 6 feet deep at mean low tide, and wide enough to enable her to work conveniently, depositing the spoils on the side toward the proposed fill. Where the water was deep a second cut would be made, widening the trench. Stone was then thrown into the trench forming a ridge 9 feet high, with slopes of 1 on 1. The trench was then further widened and deepened by a dredge with a longer boom, or with a chute carried on a scow.

An endless chain dredge was used after the first cut was made, by which the material was lifted to a height of about 12 feet and dropped into a hopper, from which it was fed to a conveyor and carried to the place of deposit. This conveyor was a line of little cars forming the links of an endless chain, supported on a frame built on scows moored alongside the dredge. By this means the embankments were raised 12 to 15 feet above low tide. Where the chute was used, the material was softened by handling, and, aided by a stream of water, would run 200 or 300 feet beyond the end of it, thus giving a very flat slope to the embankment.

This work extended over a period of seven or eight years, and about 8½ miles of embankment were thus formed. Time had to be allowed where the material was soft for it to harden, and in such cases the work progressed very slowly. The stone in the trench formed a footing for the embankment and a foundation for the dry wall that was afterward constructed. This wall from low water level was 6 feet high, 5 feet wide at the base, 3 feet wide at the top, with the back vertical, and cost $1.70 for the stone and $1.45 for the labor per cubic yard, or a total of about $2.80 per linear foot of wall.

The hydraulic dredges used on the Potomac excavated the material from the bed of the river and deposited it at the desired place on the shore with one operation. The machine consisted of a large rotary pump mounted on a scow, from which a cast iron pipe was led to the bottom of the river. The part leading into the water could be moved about a center from one side to the other, and the end of the pipe thus described the arc of a semicircle about 60 feet diameter. The pipe was made with flexible joints and was carried on pontoons to the shore. The rubber joints were a source of much expense. Under favorable circumstances 30 to 40 per cent. of the volume pumped would be solid matter, but such large quantities did not give good results; as a rule, 10 to 20 per cent. was easily handled, with the engines making 125 revolutions per minute. Working in soft material, one dredge averaged 350 cubic yards per hour for days, the length of the discharge pipe being 3,000 feet, and the height above water level 6 to 12 feet. On one occasion 800 cubic yards per hour were deposited at a height of 10 feet above mean low tide and at a distance of 1,200 feet.

Clay in passing through the pipes would take the shape of balls about 5 inches in diameter, and bowlders as large as a man's head have been forced through. A certain amount of sand and gravel could be handled when mixed with mud or clay, but pure clay could not be handled with advantage, as it cut away the shell of the pumps very rapidly. In sand the discharge pipes were also apt to fill up so as to largely reduce their capacity. On one occasion the sand in the pipes was packed so hard that forcing water through them for two days did not clear them. The water flowing through the discharge pipe at ordinary times had a velocity of about 10 to 15 feet per second.

By this method about 5,000,000 cubic yards of material have been dredged and deposited on the flats at a cost of from 12·37 cents to 15·45 cents per cubic yard. The cost of excavation by the use of the Riker pump was about 13 to 14½ cents per cubic yard.

The total amount of material deposited on the flats up to January 1, 1893, was 9,437,523 cubic yards. Converting place measurement into scow measurement on the basis of 20 per cent. excess, the average price for the whole work done would be 11½ cents, including the profit of the contractor, or a little more than one-half the cost of the same work done by means of scows and railroads on trestles. The filling of marshes in proximity to cities will often pay the cost from the enhanced value of the land created, and is usually desirable from a sanitary point of view, and the hydraulic method is in many places an economical one.

It is found on the Potomac flats that the settlement in material was very small where there was a moderate quantity of sand in it; but where it was pure mud it was considerable and long continued, amounting in three years to 2 or 3 feet, and in seven years more to 1½ feet additional.

The map shows that, according to the plans adopted, the Washington channel would be closed at the upper end and become an arm of the river, in which the tides would rise and fall, but with no tendency to clear itself. With a view, therefore, of clearing it from pollution of sewage, etc., a large reservoir was designed to receive water on the flood tide from the Virginia channel and discharge it into the head of the Washington channel at the ebb. The area of the reservoir, as laid out, was 111 acres, with a depth of 8 feet below mean low tide.

The mean duration of flood tide is about 5½ hours and of ebb about 6¾ hours, and about 14,500,000 cubic feet would be received on the average flood tide, or 29,000,000 cubic feet daily. After careful study it was decided that the inlet gate might be dispensed with, and an open connection made with the Virginia channel. It was hoped the flow of the river would keep the water level at the site of the inlet above that at the outlet, and experience has justified this.

The mud at the outlet has a depth of about 75 feet below tide. The structure for the outlet gate was built upon a pile and grillage foundation, the piles being spaced so as to receive a weight of about 10 tons each. The structure consists of a dam of masonry with six arched openings, connected to the adjacent fill on either side by wing walls. The head walls are built of granite and the wing walls of concrete, the openings are 6 feet wide and 12¼ feet high to the crown of the arch. The gates are in pairs, pivoted on vertical axes and swinging, while open, into recesses in the side walls. They butt when closed, like the gates of a canal lock, on miters at the bottom and top, and move easily on the slightest pressure. They close automatically when the tide begins to rise at the head of the channel, shutting off the passage of water into the reservoir, and as soon as the tide begins to fall they open, and allow the water to flow from the reservoir to the Washington channel.

## CRACKED PLATES.

THERE are certain classes of defects in boilers that boiler owners know about and endeavor to avoid. Among these are the deposit of sediment and scale, leakage around tube ends and along riveted joints and overloaded safety valves. These defects rather force themselves on the attention of the owners; but there are many other kinds of defects that are not so obvious, though they may be fully as dangerous. Among these less patent defects are cracked plates.

Freqently cracks start from the edge of the plate, opposite a rivet hole, in the girth joint that comes over the fire. Such cracks are often due to distress at the joint arising from an improper arrangement of the feed pipe; for if the comparatively cold feed water is discharged on or near the fire sheet, it chills the shell in that vicinity, and produces a powerful local contraction of the metal, which is quite sufficient to start the joints, or, under some circumstances, to even crack the solid plate. But whatever the cause of the cracks, they are likely to first appear at the edge of one of the fire sheets and to extend gradually inward. Often they are stopped by running into the rivet hole, and do not extend further. Frequently, however, they run past the rivet hole, or cross it, and extend into the sheet on the further side of it. It then becomes very important to check their further progress. This may often be done by drilling a small hole through the sheet at the very extremity of the crack. This hole may afterward be filled with a rivet, or it may be tapped and filled with a screw plug.

Besides these fire sheet cracks there are numerous other kinds due to different causes. For example, the strength of a plate may be injured by overheating or "burning," so as to develop a serious crack under the ordinary running conditions, without any assignable reason except that it has become too weak to withstand the strain that comes upon it in ordinary usage. Cracks are often discovered, too, along flanges that have been turned to too short a radius. Careless flanging is apt to start small cracks through the skin of the iron, and these frequently extend inward and eventually become dangerous. Incipient cracks on the inside of a boiler sometimes develop into deep grooves, the slight yielding of the shell, under varying pressure, opening the interior of the metal to the corrosive action of the water. Defects of this kind usually occur along the edge of lap joints or near stay bolts, where the shell is partially stiffened and the buckling action of the plates more pronounced.

The accompanying wood cut (Fig. 1) shows a crack

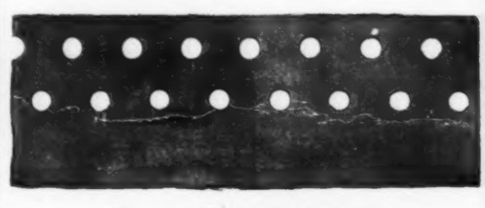


FIG. 1.—CRACKED PLATE.

due to a different cause, and it ought to carry with it a useful lesson. It represents a piece of plate that was cut from a boiler in active service and which was believed to be in good condition. The boiler from which it was taken was 48 inches in diameter, with tubes 15 feet long; and the plates were of steel, ⅜ of an inch thick. The piece of plate, shown in the cut, formed the edge of one of the sheets where two sections of the shell were united by a longitudinal, double riveted lap joint. It was taken from the upper part of the boiler, and was not exposed to the fire. It contained one well-marked crack extending completely through the plate, besides many other shorter ones, running into one another in all sorts of ways, some of them extending through the plate and others not quite through it. All these cracks were entirely covered by the inside lap of the joint, so that they could not be seen from the interior of the boiler; and on the outside, the boiler was covered at this point by a thick layer of non-conducting asbestos covering. We mention these points in order that the reader may understand how easy it would be to overlook this defect. Yet it would not be putting the case too strongly to say that, although the boiler appeared to be in good condition, it was actually on the verge of explosion. For a considerable distance along the joint the strength of the plate was entirely destroyed; and at other places it was held together by the merest skin of metal, as was afterward shown by breaking the plate across along the line of the cracks. The fractured area was almost entirely black, though bright spots were noticeable at intervals of two or three inches or so.

The cause of this defect will be sufficiently obvious to those who are familiar with the processes of boiler making. In rolling plates into the cylindrical form, preparatory to riveting them up into shells, it is customary to bend one end of the plate to what is judged to be the proper radius by the use of the sledge hammer.

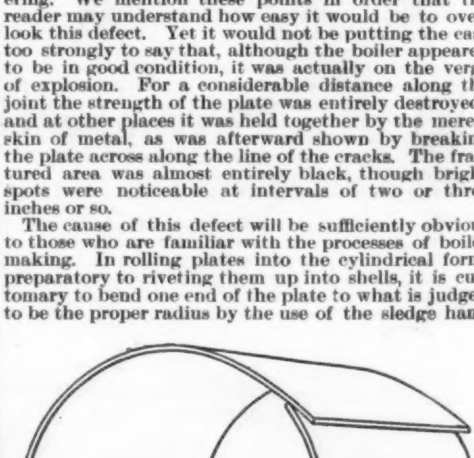


FIG. 2.—ILLUSTRATING THE "OFF-SET" OF THE LAP.

The plate is then run through the rolls and rolled into shape, the end that was previously bent being introduced first. When the plate has been rolled all but the last five or six inches, the last end slips off the first roll, and the rolls can no longer "grip"

the sheet. The result is that the last end of the sheet is not bent to the proper radius, but remains straight or nearly so. The shell (if rolled from one sheet) then looks something like Fig. 2, one end of it "standing off" from the rest of the shell. (This feature has been somewhat exaggerated in the cut in order to show more distinctly what is meant.) In order to bring the outer lap to the proper curvature, it is customary for one man to hold a sledge against the projecting edge of the lap, while another workman strikes the shell on the inside. In this way the lap is bent down into place, and after the shell has been brought to conform with the "sweep" or templet, in every part, it is ready for riveting.

Now it will be seen that the treatment required for bringing the laps together in this manner is rather violent; and it follows that nothing but the best of materials will stand it without being greatly distressed and permanently weakened. Under the sledging operation the material is likely to be strained beyond its elastic limit, unless it possesses great ductility. The greatest strain on it comes on the outer lap, at or near the line where it touches the inner one in Fig. 2. We have no doubt that the cracks shown in Fig. 1 were started in this way, and that they afterward crept into the plate gradually, as the boiler yielded slightly under varying pressures until they reached the highly dangerous state described above.

If the sledging were done while the sheet is hot, it would not be so objectionable; but the great majority of boiler makers will not attempt to heat the plate before sledging the lap down, because when the sheets are hot they are apt to buckle out of shape and give great trouble.

In the early days of steel boilers, before the manufacture of that material was understood as well as now, plates were much more apt to be injured by sledging than they are at present. Steel having a high tensile strength is almost certain to be deficient in ductility; and for this reason it is customary, in the specifications sent out from this office, to make the maximum allowable strength of plate 65,000 pounds to the square inch, when such plate is to be exposed to the fire. We also specify that the steel used shall show an elongation of twenty-five per cent. in a length of eight inches, that it shall show a reduction of area of not less than 56 per cent., and that its elastic limit shall be at least 50 per cent. of its ultimate strength. The plate should also be capable of being bent double and hammered, when either hot or cold, without showing cracks; and it is also desirable that it should stand this same test after being heated and quenched in water. Steel that possesses these qualities makes excellent boilers, and it will stand a great deal of abuse, in the boiler shop, without developing defects in after service.

In conclusion, we may say that cracked plates are not so uncommon as the average reader might suppose. This may be seen by glancing at our inspectors' reports, as published from month to month in the *Locomotive*. Thus we find that during the year 1892 our inspectors discovered no less than 2,646 plates that were cracked in one way or another, of which 658 were considered to be dangerous.—*The Locomotive.*

## IMPROVED PIPE-CUTTING MACHINE.

THE machine, by Geo. W. Dudley & Company, St. Louis, Mo., may be explained as follows: The crank motion operates a shaft actuating a bevel gear which in turn operates a toothed wheel revolving on a fixed wheel, with even bearing on all portions of its frictional surface. The revolving wheel carries the tool post; the cutting tool is worked automatically on each revolution by a cam projecting on the fixed frame supporting the crank shaft.

The width of the cutting tool is about $\frac{1}{16}$ of an inch, properly proportioned to the frictional strain of cutting. The manner of adjusting the machine is simple—by set screws, and is easily adjusted, as the first revolution of the machine will determine the accuracy of setting. The machine can cut to a bevel by adjusting the set screws. It can also cut a dovetail on the edge of the pipe for the purpose of shrinking a wrought iron bead on the edge of the pipe. By changing the cutting tool and substituting a round nose gouge tool, beads may be cut near the edge of the pipe to correspond with like beads in a bell joint if required.

IMPROVED PIPE-CUTTING MACHINE.

Repairs on large water mains, insertions of branches and gates, are in most cases attended with great risks by the time taken to do it and the fear of fire breaking out in the district while the water is shut off. The liability of disturbing weak sections of a pipe in making repairs on broken sections are observed and experienced in the necessity for breaking out by use of sledge, sections of broken pipe. The cutting and trimming of a fractured pipe frequently results in cracking other parts of the pipe. Damage to the eyesight of workmen by cutting, chipping, and breaking off iron into small fragments frequently occurs.

By the use of this machine the time taken out of the service for distribution, in making repairs and alterations, is reduced fully two-thirds, it is claimed, compared with old methods, and that other difficulties disappear.—*Master Steam Fitter.*

## VELODROMES OR PERMANENT TRACKS FOR BICYCLISTS.

OF all modern sports, cycling is certainly the one that has most quickly taken root among us. From the beginning, it gave rise nearly everywhere to races, which, despite their necessarily defective organization, have not a little contributed toward diffusing this sport. Now that Queen Bicycle has the freedom of the city with us and that powerful associations have been formed on all sides and notably in the great centers, the need has been felt of the creation of velodromes, that is to say, of closed fields in which racers and amateurs can devote themselves at their ease to their favorite exercise. Independently of the security that is obtained by a track essentially tight, that is to say, closed on every side, they can find here medical attention within their reach, and at the same time a private room in which they can rest at their ease and change costume. The English, much in advance of us, have had such tracks for a long time.

In France, it was Bordeaux that gave the example. As long ago as 1885, the Velo-Club, of that city, constructed the Saint Augustin track, which was 375 meters in circumference. A few years later the tracks of Jarnac and Pau appeared simultaneously, and finally that of Courbevoie, at Paris. This latter, copied after the English tracks, was provided with elevated curves that allowed the racers to pass over them without danger and without slackening their speed.

Since 1890, we have seen appear in France the tracks of Buffalo at Paris, of the Velodrome of the Park at Bordeaux (Fig. 1), of Lille, of Reims, and finally the track of the Velodrome of the Seine, at Paris, which seems to be a model of its kind.

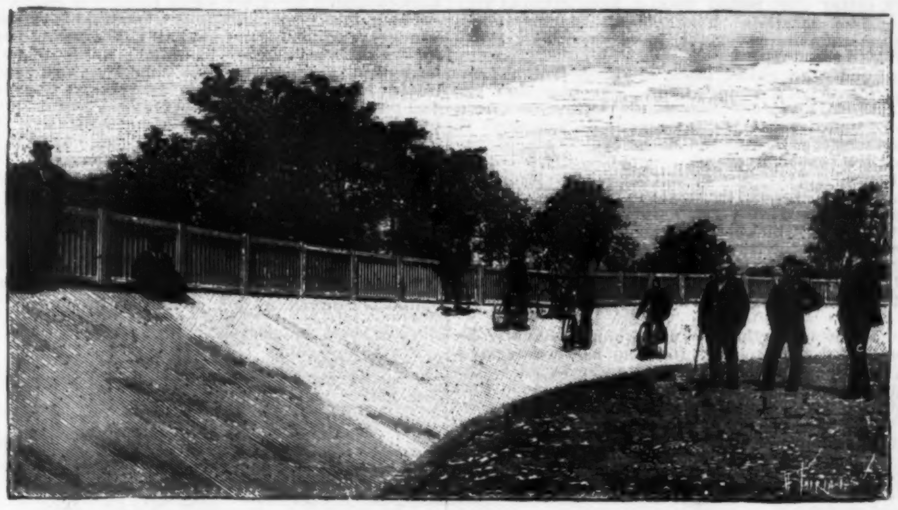


FIG. 1.—BICYCLE TRACK OF THE PARK VELODROME, AT BORDEAUX—AN ELEVATED CURVE.

Cyclists, by reason of the ease with which their machine is steered, have no need of a track presenting a great circumference, and, contrary to what happens in horse races, bicycle races gain by being run in a circumscribed space, because the spectators much more easily follow all the phases of the contest.

Now, a circuit that varies from 333 to 500 meters necessarily has elevated curves of quite feeble radius. To pass over them, the racer, rushing forward at a speed that to-day reaches 50 kilometers an hour, is obliged to lean inwardly in order to combat centrifugal force. In this position, the wheels of his machine would swing if the ground were horizontal. It is for this reason that one has been led to form curves sloping from the exterior to the interior and the inclination of which should be so much the greater in proportion as the radius is smaller and the speed greater. This is what is called the rise of the curve. If such rise be well calculated, when the racer passes at the greatest speed his machine should have its vertical longitudinal plane perpendicular to the earth of the track.

Exact calculations would be quite difficult to establish in order to reach a normal rise, for there enters into the calculation an essentially variable element—the weight of the racer. It is preferable to adhere to the results of experience, and we have established on this subject an empirical formula $\frac{15}{2R}$, which, up to the present, has given very good results.

Generally, in order to establish these elevated curves, the ground is leveled as much as possible, and then earth is brought and formed into a shelving ridge, of which Fig. 2 gives a sectional view. The form of the track has been previously decided upon. According to the ground at one's disposal, two straight lines connected by two arcs of a circle, whose radius should not fall below 25 meters, are provided for (this is the classic form), or else a track is made having an elliptical form, and which is composed only of arcs of circle connected with each other.


FIG 2.—ELEVATED CURVE OF EARTHWORK.

We have here, moreover, two systems, in presence of which each has its partisans, and the respective merits of which we do not care to discuss. Let us merely say that both have their advantages and disadvantages.

On the subject of the rise, of which we have just spoken, we should mention the pronounced subsidences that take place in the earthwork of the elevated curves, and that habitually occur every time an embankment is established. On another hand, rain, in the long run, wears away the back slope of 2 meters in 3, seen to the right of Fig. 2.

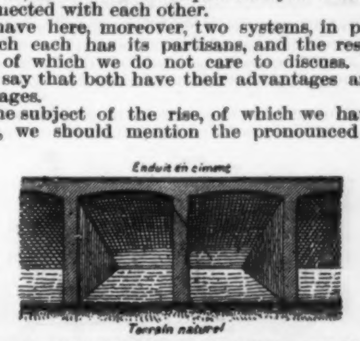



FIG. 3.—VAULTED ELEVATED CURVE.

In order to obviate this, there has been inaugurated at the Park track, at Bordeaux, a system of elevated curves constructed upon vaults (Fig. 3). These vaults are entirely of beton, and, along with the vertical

walls, are moulded on the spot. The space between each wall is 2 meters; the thickness is 0·10 meter, and all the directions are concentric. These curveways are more costly than those made of carted earth, but they assure a greater stability on the surface of the track, which, in the other case, experiences risings and settlings, due solely to the slow and irregular subsidence of the filling.

In England, the superstratum of the first tracks was composed of ashes and pounded bricks, forming a layer of 0·10 meter that rested upon a foundation of very solid coarse materials. This was already very good, but numerous improvements have since been introduced into the track.

At present, the model track of Herne Hill, at London, is formed of a wooden floor. The objection has been made to this sort of track that it possesses a certain flexion; but, despite this, the speeds do not seem to feel the effects of it, and the Herne Hill track is considered the best in England.

In France the majority of the tracks are formed of a stratum of beton from 15 to 20 centimeters in thickness, covered with a smooth coat of cement mortar 0·01 meter in thickness. This was the method of construction of the track of the machinery gallery at the Champ de Mars, Paris. Such tracks afford high speed, but, when they are not under shelter, the elevated curves become slippery when they are wet by rain.

A new system has just been inaugurated at the Velodrome of the Seine, in employing a wooden pavement analogous to that of streets, except as to the thickness, which does not need to be so great, seeing that with the rolling of cycles it can be anticipated that the wear will be null. This mode of construction is very costly, but the track will last indefinitely without repairs, and, upon the whole, in the long run, a saving will be able to be effected by this fact.

A track, in order to be safe, should be completely inclosed externally.

In the interior, on the contrary, there should be no inclosure, for at a critical moment a racer must be able to betake himself to the greensward.

The velodrome, in order to be complete, should be provided with a sprinkling apparatus and a restaurant, or at least a refreshment room. There already exist a dozen velodromes in France, and many others are projected or are in the course of construction. This is a consequence of the favor that cycling enjoys at present.

From the standpoint of physical exercise, we should rejoice at this, for, of all sports, cycling is the one that develops the most organs at once. Medicine, for a moment rebellious, has entirely changed its first manner of looking at it, and the heads of the profession do not hesitate to preach by example.—*La Nature.*

## A BICYCLE TOURNAMENT.

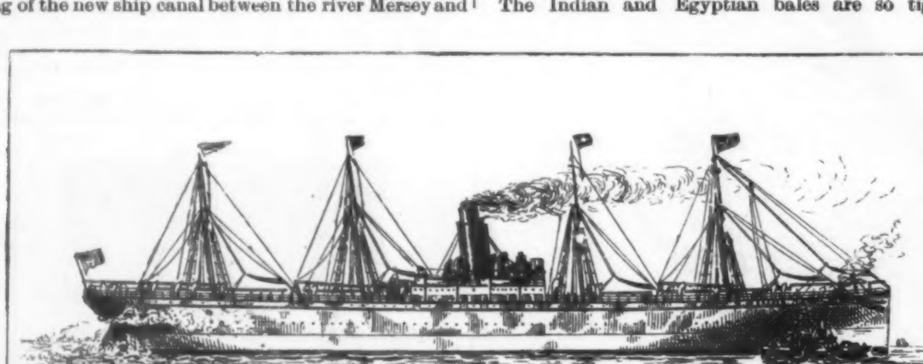
THE greatest six-day bicycle race ever held in the world was brought to a close Saturday, Dec. 30, at ten o'clock in the evening in the presence of thousands of spectators. The race was held in Madison Square Garden, New York City, the great length of this building offering an excellent track for bicycling. The race was a very successful one from almost all standpoints. Every record has been broken by Schock, the new champion, who won easily, breaking the record with twenty-four hours to spare. Waller, the German, who came in second, showed remarkable speed and endurance, but he was lacking in ambition and courage, and it was with difficulty that he was kept on the track by his friends and trainers. Martin (the champion of 1891) came in third, and did remarkably well, considering his bad physical condition, as he was attacked by a serious stomach trouble the second day of the race. The expenses at the Garden were very heavy, so that the winners were disappointed in not receiving a share of the net receipts. The official score at the close of the race was as follows.

| | Miles. | Laps. |
|---|---|---|
| Schock | 1,600 | 3 |
| Waller | 1,484 | 8 |
| Martin | 1,430 | 1 |
| Albert | 1,410 | 1 |
| Van Emburg | 1,401 | 1 |
| Golden | 1,313 | 1 |
| Meixell | 1,190 | 0 |
| Forster | 1,045 | 0 |
| Barton | 1,006 | 3 |
| Ashinger | 879 | 2 |

## STEAMER FOR THE MANCHESTER SHIP CANAL.

WE publish a sketch of a very large and fine steam vessel which has been lately built to run between Manchester, England, and New Orleans. By the opening of the new ship canal between the river Mersey and Manchester, the latter city has lately become a seaport. Our engraving is from *The Engineer.*

It represents the steamship Sachem exactly as she appeared steaming away from the Abercorn Basin, where she has just been finished by Messrs. Harland & Wolff. She has been built for Messrs. George Warren & Co., Liverpool, and has a gross tonnage of about 5,230. She is intended for the cattle trade, two decks being fitted up for their proper and safe conveyance. She has a double bottom for water ballast, and deep tanks adapted for either water ballast or cargo. The Sachem has four masts—of a peculiar form—steam winches, steam windlass, and all the latest appliances for the rapid and efficient handling of cargo, and will be lighted throughout by a complete installation of electric light plant. She is driven by a single screw and powerful triple-expansion engines, supplied by her builders. In reference to her masts, it will be noted they are very short and stumpy, and only provided with topmasts for the sake of appearance. These would, of course, be struck on entering the canal to permit of her passing under bridges.



THE MANCHESTER SHIP CANAL STEAMER SACHEM.

## AMERICAN, EGYPTIAN, AND INDIAN COTTON BALING.

THROUGH the kindness and courtesy of the largest spinning concern in Chemnitz I can give the department definite and very desirable information, backed up by photographs.

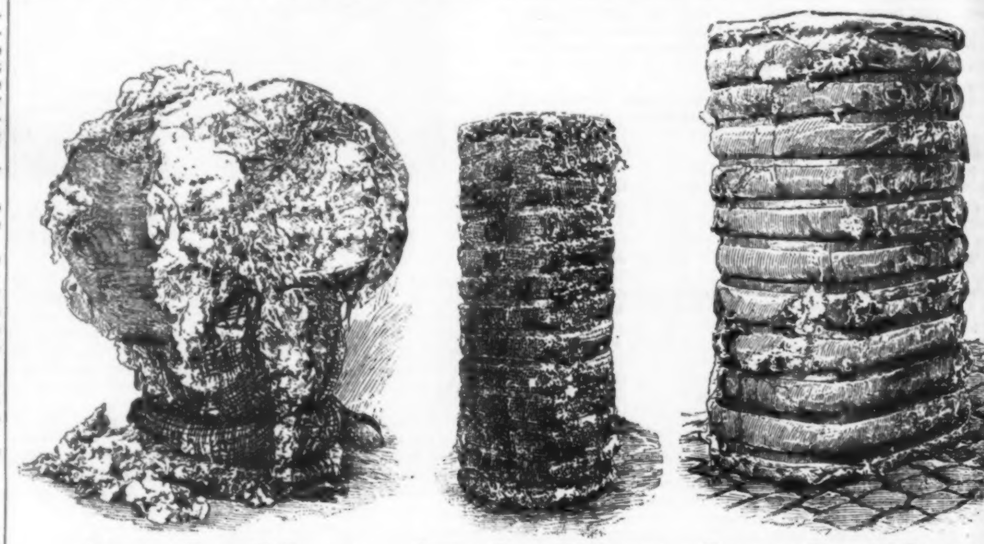
The packing of American raw cotton causes a deal of anxiety and complaint here. The jute cloth covering is so torn before the bales reach Chemnitz that the cotton is exposed to mud, water, fire, and theft. Of the original six or eight iron bands, two, three, four, and sometimes more are loose or broken; the cotton bulges out, takes up dirt and dust when in a dry place, mud in the docks, sea water when in the ships, and rain water when on land, on wharves, or in transmission by boat, rail, or wagon. In transport every gust of wind tears away pieces of the valuable commodity. The wharves, custom house floors, and freight cars are usually covered with pieces torn or dropped from such bales; and the danger from fire is great, for cotton ignites easily, and sparks from cigars or locomotives, fanned by winds, even those caused by the movement of a train or wagon, could cause not only the burning of the cotton, but of other valuable property.

Contrasted with the packing of Egyptian and Indian cotton, the American must be regarded as very bad. Both Egyptian and Indian have close, compact, tough coverings, are rather long and smooth, leave little or none of the cotton exposed, are easily and plainly marked, and are wrapped close and bound strong and tight. Along the sides the firm's or seller's name appears. On both ends the kind of cotton is indicated to aid in identification, should one end be torn off in handling, as sometimes happens. Thus, in the case of Indian and Egyptian cotton, mixing of bales with and without marks seldom if ever occurs; on the other hand, with American cotton both happen very frequently—too frequently, hence the complaint.

The Indian and Egyptian bales are so tightly pressed, so well covered and bound, that injury from fire, water, dirt, dust, etc., is minimized. Take this table as to space occupied by the different bales:

| Bales of Cotton. | Weight. | Space occupied. |
|---|---|---|
| | Pounds. | Cubic feet. |
| Egyptian | 70 | 15 |
| Indian | 400 | 10 |
| American | 475 | 22 |

The Lloyd's, who can pack into their vessels' holds 16,000 to 18,000 bales of Indian cotton, can take only 6,000 to 10,000 American, when, according to the ratio of weights (4 to 4¾), they should take in 14,000 bales. Consider this in the figuring of expenses, where \$3, \$4, \$5, etc., are paid per cubic yard for ocean freights. What appears here in the matter of ships holds equally good in relation to transport wagons, room taken up in freight houses, magazines, and storehouses, etc., all of which add to the expenses. I am informed that producers, as well as manufacturers, have to pay "enormous sums" for these "unnecessary" expenses. Besides, the American planters waste large quantities of unnecessary packing material. The losses by dirt, dust, mud, bursting of the bales, by stealing, etc., affect the producer and manufacturer in about the same ratio.



AMERICAN BALE, 500 POUNDS. INDIAN BALE, 400 POUNDS. EGYPTIAN BALE, 700 POUNDS.

COTTON BALING.

The increased danger of fire increases the premiums on fire insurance policies. The mixing of the bales and the "no mark bales" cause no end of confusion. More secure packing, a much closer pressing, and greater care in covering or wrapping up, would be of inestimable and permanent benefit to the cotton trade of the United States.

Planters formerly entertained a fear that the enormous pressure used in India would injure the fine fibers of the American cotton, would make more difficult the processes of cleaning, and would cause the formation of small knots which would injure the carding machinery, but such belief has disappeared. The fact that Egyptian cotton, with as fine or finer and longer fiber, has stood greater pressure satisfies everybody interested that the time has come for a reform in American methods of packing. Of course, great care is to be taken before packing to see that the cotton is perfectly dry; otherwise, internal fermentation will create "cakes," resulting in the same danger to the carding machinery as that caused by the little knots described above. Egypt and India have small fear of these dangers, because of their particularly dry climate, especially during the packing and shipping season.

The photographs of these bales of cotton as they reached the spinning mill at Chemnitz tell their own story more graphically than words can tell it.

J. C. MONAGHAN, Consul.

Chemnitz, October 14, 1893.

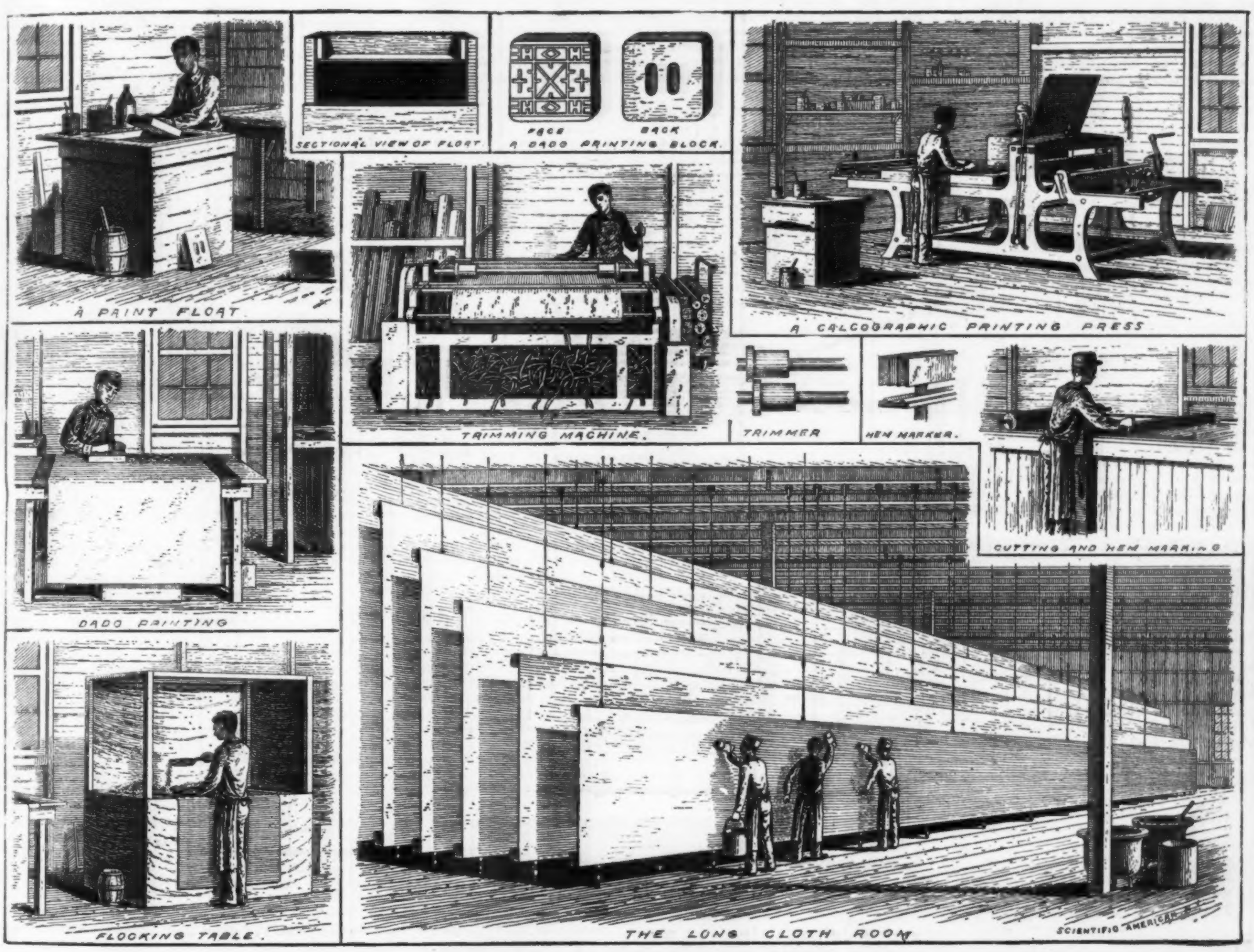
## HOW WINDOW SHADES ARE MADE.

THE illustrations of this subject were taken from the manufactory of the Calcographic Window Shade Co., Jersey City, N. J. The standard shade at the present time is the sun proof holland. The first operation in their manufacture takes place in what is called the long cloth room. Fastened to the beams above, about 25 ft. apart, are tracks containing a number of trolley wheels suspended from which are short pieces of heavy wire linked together. Pieces of timber, placed end to end, running the length of the room, are hooked by means of screw eyes to the ends of the wires. Strips of the best grade of muslin, 175 ft. in length and ranging from 3 to 10 ft. in width, are tacked and pasted on the top and bottom edges to these pieces of timber. They are then drawn taut by means of pulleys connected to the floor and bottom pieces of timber. The muslin is then sized over with glue and water. When dry the painting operation begins. Instead of the old method of putting it on with the brush, it is now put on with muslin stretched over wooden blocks, which causes the paint to be rubbed thoroughly into the muslin. This requires the labor of three men to a strip. The first man puts the paint on roughly; the next man smooths and levels it, and the third man rubs it in and finishes it. The strips are painted in different tints. The ingredients are a mixture of zinc, oil and white lead. The room is heated for drying purposes to a temperature of 70°. After drying the strips are removed and taken to the trimming machine. The painted muslin is first rolled around a circular iron rod and placed in one end of

the machine. The strip passes over and under eight steel rolls, about 1½ in. in diameter, during the operation of trimming.

The second, fourth and seventh rolls are raised by means of the lever at the side of machine, when the attendant places the end of strip in position for trimming. As soon as the strip is in place the lever is pushed back and the rolls are drawn back in their sockets. The pressing down of the rolls keeps the strip smooth and in place as it passes under the trimmers. There are two trimmers on each side of the machine, one over the other. They can be moved back and forth on the roll or shaft and gauged to cut different widths of shades by means of a screw. The trimmers are made of steel and are about 3 in. in diameter, with a ¼ in. flange at one end. The outside edge of the flange of the lower trimmer just grazes the inside edge of the upper trimmer. This causes the strip to be cut as it passes through.

The material is taken up by another roll at the end of the machine. It is then taken to the cutter and hem marker. The hem marker is made of two bars of steel about 2 in. in width, 4 ft. in length, 1½ in. apart and grooved on the under side. These bars are connected at each end to a circular rod 1½ in. in diameter. Directly underneath the grooved bars is a steel plate, the sides of which are raised, like the shape of a triangle. The rods pass through the center of this plate and down to a foot lever below. The attendant then passes enough cloth for a shade underneath and between the rods. The lever is then pressed down, forcing the grooved bars down over the raised surface of the plate, which makes an impression for the hem. A knife is then passed along the side of bars separating the shade from the roll. The shades are then taken to the printing press. The designs are printed from etched plates. The rolling beds of the presses are made of iron and are hollow. They are 4 ft. in length, 3 ft. in width and 4 in. in thickness. The etched plate is placed on the center of this bed and a hand roller coated with paint is run over it. The end of shade to be printed is carefully placed over the plate, with a heavy strip of paper on top. Over this is placed a thin sheet of steel. The bed, which rolls on wheels attached to the sides of press, is pushed forward under a sheepskin scraper. The lever is then drawn forward, which forces the scraper down on the steel plate. The press is then set in motion by an attendant turning the crank. This draws the bed containing the plate through the press. The pressure of the scraper on the steel sheet causes the impression to be made on the shade. The bed is then drawn back, the printed shade taken off and another placed over the plate to go through the same operation. The printed shade is then coated with pulverized wool called flock. Dados are printed from blocks. They are 1 foot square and about 3 in. in thickness. The design is made of small strips of sheet brass projecting out about ⅛ in. from the surface. To print, the face of the block is first placed in what is called a paint float. This is a box-shaped contrivance, about 2½ ft. square and 3 ft. in height, containing an 8-in. zinc-lined reservoir filled with water, resting on the surface of which is a shallow box with a canvas bottom. The block is placed face down on the canvas bottom, which is covered with a thin coating of paint. By pressing the block against the canvas every part of the design is at once covered with paint. The operation of printing is then begun by pressing the block on one corner of the shade, printing about 1 foot at a time, and repeating the operation until the dado is finished. After the shades can be handled they are taken to the hemming room, where they are finished and made ready for shipping. The printing presses will turn out about 100 pairs of shades per day each.




MANUFACTURE OF WINDOW SHADES.

## THE WASTE OF ANTHRACITE.

By HENRY WURTZ, Ph.D.

IT may be stated, at the outset of this article, that some of the more important facts conveyed therein are derived from an address of Eckley B. Coxe, Esq., as president of the American Society of Mechanical Engineers. Mr. Coxe is stated to be the largest individual coal miner and producer in the anthracite regions—employing much the largest number of men—and has passed his whole career, rising to position and distinction, in this pursuit. His complete familiarity with the subject, in all its aspects and prospects, past, present and future, is undeniable; and his reliability admits of no doubt. To this it may be added that he has from the first been a member of the Pennsylvania State Commission, appointed some years ago to investigate this great problem of the apparently lavish and wanton waste of one of Mother Earth's greatest treasures, the "solidified sunshine" that she has buried in her bosom for us, her offspring.

The above remarks are here thrown out, in view of the great mass of confused, conflicting, biased and often erroneous opinions that have been entertained relative to this subject, in its various bearings and connections. It will be well to regard such positive statements as we find made by Mr. Coxe as entitled to all confidence.

Some of us may remember the early days when all the anthracite was delivered to the retail trade, and often even to private consumers, in the *lump* form just as mined, and had to be broken up by hand tools. Then came up gradually the great machines called coal breakers, in which it is now crushed with magic rapidity by the most ponderous machinery, then picked over by hand or by other machinery, screened, sorted and gradated mechanically, at present into at least nine different sizes, each of which has, or rather should have, its special functions to fulfill. In the case of the smaller sizes, the character of the functions of these appears yet to involve mooted points, and to be still a matter of investigation and of controversy. In such investigation Mr. Coxe has taken an active part.

The names now usually attached to the nine different sorts of screened and sized anthracite now offered in the market are as follows, beginning with the largest size: 1, lump; 2, broken; 3, egg; 4, stove; 5, chestnut, or simply nut; 6, pea; 7, buckwheat; 8, rice; 9, barley.

The names of Nos. 8 and 9 are novel to the writer, being of rather recent origin, and applied to what have been sometimes called Buckwheat No. 2 and Buckwheat No. 3. Mr. Coxe, to convey ideas regarding the average sizes of the smaller of these sorts, which are not so familiar to most consumers as the larger sizes, tabulates them as follows, with the dimensions of the (round punched) screen meshes used in sorting them; adding further the prices at the mine:

| | Made through. Inch. | Made over. Inch. | Approximate price at mines. |
|---|---|---|---|
| Chestnut | 1⅛ | ⅞ | $2.75 |
| Pea | ⅞ | 9-16 | 1.25 |
| Buckwheat | 9-16 | ⅜ | 75 |
| Rice | ⅜ | 3-16 | 25 |
| Barley | 3-10 | 3-32 | 10 |

He states also that the cost of transportation of the small sizes is less than that of the large; 30 cents per ton less than domestic sizes, for pea size to tidewater, and 50 cents less for rice and barley sizes.

As was to be expected, obstacles have been encountered in the attempts to make markets for the smaller sizes, called rice and barley coal. The grates in use for the larger sizes of course could not burn these to advantage, and consumers naturally objected to putting in new grates, and remodeling their fireboxes in other ways, as required to obtain results comparable with those from larger coal. Mr. Coxe himself has invented a furnace especially adapted to the burning of the small sizes, something on the "base-burning" principle, combined with an endless traveling grate. This is figured and described in the *Engineering and Mining Journal* for July 8, 1893, page 34.

Extensive experiment has proved to Mr. Coxe that there are three main causes of ill success in the use of these small sorts, as prepared at some collieries:

*First.*—Bad, that is *irregular* sizing, which leads obviously to obstruction of the draught, from the choking up of the interstices between the larger granules by the smaller ones.

*Second and Third.*—These depend reciprocally on each other, being low percentage of carbon and high percentage of ash. He has found that with the small, as with the larger sizes, the amount of steam made per ton of coal depends on the amount of carbon, not on the size; but for equal heating surface the amount of steam made in equal time decreases with the size of the coal. Mr. Coxe himself burns as much as 150,000 tons per year of the small sizes for making steam, and finds it a matter of much personal advantage to exercise care and skill in its preparation, and insure by chemical determinations, carried on continually, of the amounts of carbon and ash, as well as of the specific gravity, keeping the smaller sizes up to the mark. The amount of ash increases curiously with the diminution in size, contrary to what was formerly the popular opinion. This fact was observed in 1886, by Mr. Ashburner (formerly of the Pennsylvania Geo-

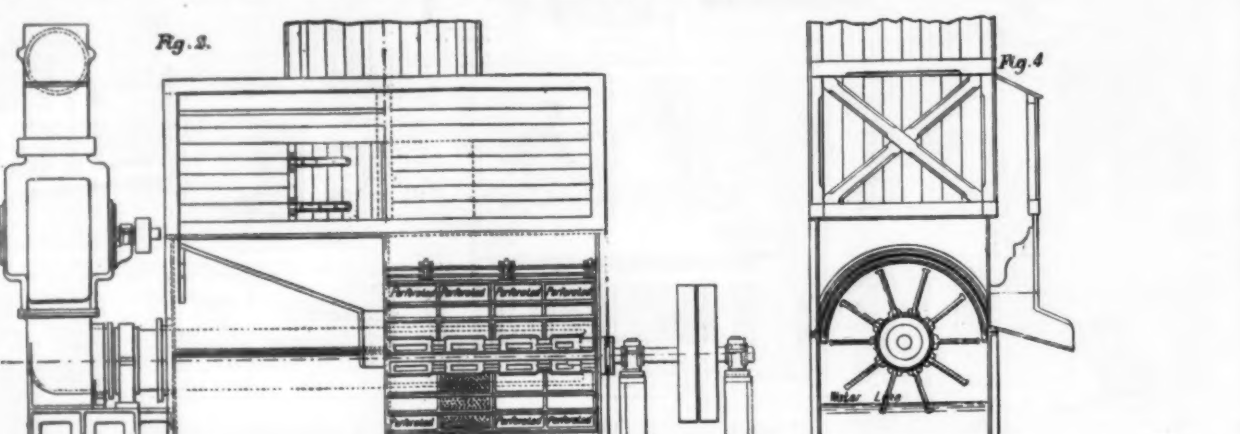
logical Survey, now deceased). Ashburner found for different sizes from the same breaker taken at the same time: For the ash in egg, 5·662; in stove, 10·174; in chestnut, 12·666; in pea, 14·664; in buckwheat, 16·62.

Coxe obtained for ash the following figures:

| | Per cent. |
|---|---|
| In lump coal | 5·00 |
| In broken coal | 7·52 |
| In egg coal | 8·50 |
| In stove coal | 8·39 |
| In chestnut coal | 9·50 |
| In pea coal | 11·45 |
| In buckwheat coal | 9·87 |
| In rice coal | 13·85 |
| In barley coal | 13·05 |

Special precautions are required in the sampling, or great errors may result in these ash estimations. The writer gathers from Mr. Coxe's remarks on this head that the reasons for these results must lie in the modes of occurrence of much of the mineral impurity in anthracites. Pyrites and some other minerals often occur in thin cross seams in the coal; being, through their thinness, fragile, and cleaving off easily from the larger fragments, thus concentrating in the smaller sizes. It would seem that thin slaty and possibly "bony" seams must often partake of this same easier detachability. Before Ashburner obtained his results in 1886, the general opinion was that the smaller coal was liable to be freer from ashy impurity than the larger. Now, however, that Ashburner's figures are so entirely confirmed by Coxe, we must regard the principle as established that the smaller the size the more ashy. This throws something of a damper on the prospect of utilizing the immense culm heaps throughout the anthracite country. Nevertheless ways may yet be found. Difficulties, in order to be overcome, must first be completely and correctly comprehended.

The report of the Pennsylvania State Commission on anthracite waste, published last June, says that the amount of anthracite that had been mined up to that time was in all 902,000,000 tons—estimating that 315,700,000 tons in all have been sent to the culm banks. Much of the latter amount has been lost through being washed away and set on fire and by being made into railroad embankments, etc. Still, very likely 100,000,000 tons may remain, much, however, in a rather impure condition. It can be partially purified; and operations have been carried on at several points, such as Rondout, N. Y., and Mahanoy City, Pa., to make it into briquettes, or "eggettes," so called, with pitch, but the pitch has been found too costly and uncertain in supply. It has been burned successfully to some extent in admixture with bituminous culm—an ancient plan; and it has been shown that such a mixture may be caked with success, and forms a good fuel. The writer suggests a trial, for caking it, of wood pulp gelatinized by zinc bichloride.




IMPROVED SMOKE ANNIHILATOR.

## IMPROVED SMOKE ANNIHILATOR.

WE illustrate Elliott's smoke and fumes annihilator, which, *Engineering* says, has been at work at the Birmingham Mint for several months, and to inspect which a number of engineers from London and the provinces lately visited Birmingham. The principle of the invention, which was experimentally tried in London two years ago, is to wash the smoke thoroughly and to utilize the carbon precipitated in the water as well as the fluid drained off.

Fig. 1 shows the general arrangement of the installation. The stack, which is 100 ft. high from the ground level and 6 ft. 6 in. in diameter, takes the smoke from three Lancashire boilers, one 30 ft. by 8 ft., and two 28 ft. by 7 ft. 6 in., each with two flues, and a three-flue boiler 22 ft. by 6 ft. In addition there is discharged into the stack the smoke from six large mufflers for hot rolling and annealing.

Formerly the Birmingham Mint was occasionally fined for allowing dense smoke to be emitted from the stack, and this, in large measure, induced the directorate to try Elliott's invention after seeing it at work at his establishment at Newbury, Berks. The fumes, instead of being allowed to pass up the chimney, are drawn off by fans at a height of about 12 ft. from the ground. Fitted into the shaft or stack is a cone with the large end downward, reducing the diameter at top to 3 ft. 6 in. An 18 in. pipe pierces the shaft, but it is proposed to substitute a 30 in. pipe, for reasons which we shall indicate later. This pipe, shown in Fig. 1, is connected to the induction opening of a fan, the casing of which is shown on the front elevation and half longitudinal section (Fig. 2), as well as on the plan (Fig. 3). This is a four-vane fan with ordinary flat surfaces, and has been found to work more satisfactorily than many other arrangements. The diameter is 3 ft. 6 in., and it is driven by belting as shown; it runs at a speed of about 1,600 revolutions per minute.

As the function of this fan is to arrest the progress of the smoke up the chimney and drive it into the washing chamber, or annihilator, as it is called, it is necessary that it should work efficiently; otherwise smoke will find its way up the chimney, and, although the stack might under certain conditions be dispensed with, there would still be necessary a sufficient induction draught to insure combustion in the boiler. It is desirable that the air pressure given by the fan should be 10 in. according to the water gauge, but at the speed given it is from 8 in. to 9 in. It is proposed, however, instead of driving the fan from a separate engine, to convey the motive power from the hot rolling mill engines through a shaft underground for 50 ft. This shaft will run at 100 revolutions per minute. It is hoped by this means to increase the speed of the fan, which, combined with a larger pipe already referred to, will give greater efficiency. The fan it may be stated is cleansed from sooty deposits by jets of water which play upon it and the bearings.

The smoke is forced through a pipe into a revolving barrel fitted with long blades as shown in the end section (Fig. 4). This revolving barrel, which is of cast iron, is about 11 ft. long and 16 in. in diameter. It is perforated with holes from ¼ in. to ⅜ in. in diameter, and fixed to it, as shown, is a series of beaters like the blades of an old-time paddle steamer. These blades also are perforated, as indicated in Figs. 2 and 3. In the cast-iron casing in which this revolving barrel works there is a quantity of water, as shown on Fig. 4, constantly replenished by a small jet entering from the top. The smoke passes through the pipe into the interior of the revolving barrel, and thence through the holes.

The result of the beating of the water is to insure the precipitation of all the carbon and sulphur in the smoke or fumes. The barrel, driven by belt gearing, makes from 180 to 200 revolutions per minute. Over the chamber are semicircular coverings or gratings, shown in section in Figs. 2 and 4, and on plan in Fig. 3. These are simply to prevent the water or carbon finding its way to the upper part of the shaft. The hot vapor given off readily passes through the perforations and up the timber trunk shown on Fig. 1, and finds its way into the chimney or stack about 50 ft. or 60 ft. above ground level.

Opportunity was afforded of ascertaining the effect of the working of this apparatus recently. The stack was giving forth smoke when the mechanism was started, and in five minutes there was a very perceptible change, while in eight minutes only a grayish white vapor was emitted, and this was easily dissipated. Dr. Heaton, of Charing Cross Hospital, made analysis of the discharged gases, and stated in his report that there was not detected any trace of sulphurous or sulphuric acid, while carbon was also entirely absent.

The residual products collected in the annihilator are utilized for various purposes. The scum passes out from the chamber as shown on Figs. 1 and 2, and into a wooden box shown on Fig. 3. Here it appears as a black and opaque bubbling liquid, the analysis of which by Dr. Heaton is given as follows:

"The liquid was slightly acid. Qualitative analysis showed the presence of copper, iron, sulphates and chlorides, and the absence of zinc and sulphurous acid.

"The liquid contained, in 100 grain measures:

| | Grains. |
|---|---|
| Combined water and volatile matter | 0·646 |
| Ash | 0·558 |
| | 1·204 |

"Complete analysis gave the following results:

| | Parts per cent. |
|---|---|
| Sulphate of iron (green vitriol) | 0·40 |
| Sulphate of copper (blue vitriol) | 0·30 |
| Sulphate of ammonia | 0·08 |
| Sulphuric acid (free) | 0·005 |
| Insoluble organic matter | 0·022 |
| Volatile organic matter | trace |

"It is evident that the important constituents here are the sulphates of iron and copper. The following experiments were made to determine whether any appreciable quantity of tar compounds was present: 1. A portion of the liquid was shaken with ether and a little acid. The ether, when decanted and evaporated gently, yielded a residue too small to be weighed, and which, when tested, was found to contain no trace of carbolic acid. 2. Two other portions of the liquid were treated respectively with acid and with alkali. Each was distilled separately, and the distilled portions extracted with ether as before. Practically no residue was contained in either case, but the distillate from alkali after ethereal treatment developed on the watch glass a slight smell like creolin."

The liquid is drained off through a sieve, and is said to have valuable properties as a disinfectant, for which it is already sold commercially, while the carbon is used for many purposes after it is dried, notably for arc lamps. The plant at the mint is worked by a 40 horse power engine and portable boiler, which is fitted with a similar arrangement for smoke prevention, but here the vapor passes off from the annihilator into the air.—*Engineering.*

## THE STEREOSCOPIC LANTERN.

RECENTLY, a private demonstration of the above was given to members of the press, at Pall Mall, under the auspices of the P. S. G. B.

Numerous experiments have been made to enable a large audience to see stereoscopically pictures projected on a screen, but we believe that this is the first successful demonstration given in England.

The subject is one which is not easy to understand without full diagrams, but we must try and explain it as simply as possible without the same, as we have not, unfortunately, had time to prepare them.

In the stereoscope the great principle of relief is obtained by the right eye seeing the right hand picture, and the left eye the left hand picture. To make this more clear, we quote the following from Mr. W. I. Chadwick's "Stereoscopic Manual," which puts the case very clearly: "We will suppose a photograph to be taken of a square box. We should produce an outline such as would be seen by one eye placed in the position of the lens. Now, by removing the camera to a position two and a half inches to one side, we should produce another outline, and we see more of one side than is shown in the previous picture. Then of course these pictures are not alike, and if we caused them to overlap they would not coincide, and we should still see two different pictures, for they could not be united as one. If, now, the reader will 'use his reason rightly,' he will be able to comprehend the fact that if these two dissimilar pictures—pictures such as would be seen in nature by each eye—were to be presented to each eye at the same angle of convergence that would be necessary when both eyes were used in viewing natural objects—that is to say, if the pictures were placed side by side (at suitable distances) and the right eye photograph viewed with the right eye, and the left

FIG. 1.

FIG. 2.

FIG. 3.

eye photograph viewed with the left eye—the brain would combine them, and we should see only one as in nature; and if these conditions were fully and correctly observed, we should perceive the same solidity and relief from the pictures that is due to binocular vision when observing natural objects."

Having explained thus far, we may now proceed to explain the principle of Anderton's stereoscopic lantern. An ordinary stereoscopic transparency is cut in two and each half mounted as a lantern slide, and the two images projected from an ordinary biunial on to a screen. Now these pictures are dissimilar, as pointed out above, that is, one is a right eye (we use this term to make it clearer) picture and the other a left eye picture, and, therefore, they cannot be made to coincide, and the result is more or less of a jumble. The thing that is wanted now is some means of enabling each eye to pick out its own particular picture, and how this is done we can only explain by digressing again on to the subject of polarized light.

There are certain bodies in nature which have a peculiar action upon light. Iceland spar is such a substance, and it has the peculiar property, when a beam of light passes through it in any direction save that of the optic axis, of always dividing the light into two beams of equal intensity; and when either of these two half beams is sent through a second piece of spar, it is usually divided into two beams of unequal intensity; and there are two positions of the spar in which one of the beams vanishes altogether. On turning the spar round this position of disappearance, the missing beam appears and the other one becomes dim. The figures herewith may make this plainer. Let Fig. 1 represent two bits of spar placed one on top of the other, with their axes represented by the central line, parallel. Light readily passes through these, but let us see what will happen if we turn them round first as in Fig. 2, and finally in Fig. 3. In Fig. 2 this light begins to get dim; as represented by the shaded portion in Fig. 3 it is quite black, or no light passes through at all. The light is polarized.

Unfortunately, Iceland spar is not now to be had in any size pieces without flaws, so that we have to look about us for a substitute, and this is found in glass. If a bundle of thin colorless glass plates—the number is not of very great moment—be bound together and placed at a particular angle, which is 54° 35' to a beam of light, the bundle of plates acts like Iceland spar, and polarizes light perfectly, and therefore if we place another bundle of plates with its axis parallel to the first as shown in Fig. 1, light will pass through without any trouble, and if we turn the upper bundle, the light gradually goes through the phases of Figs. 2 and 3.

With a powerful beam of light it is not essential, to show this phenomenon, that the glass plates be in contact; in fact, provided the beam is powerful enough,

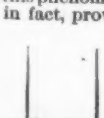


FIG. 4.



FIG. 5.

the distance between the two bundles of glass plates is immaterial. The crystal of Iceland spar, or bundle of glass plates through which the light first passes, is called the *polarizer*; the second crystal, or bundle by which the light is examined, is called the *analyzer*.

Now, possibly, having cleared the way, we may be able to explain Anderton's stereoscopic lantern. It is an ordinary biunial, fitted with lime light, and, as stated above, an ordinary stereoscopic transparency is cut in two, and one half placed in each lantern. On the front of the objective is slipped a short tube containing a bundle of glass plates We believe that Mr. Anderton uses about thirty plates, placed at the polarizing angle, and in front of the bundle is an aperture, oblong, with 1-in. sides; this forms the polarizer. In one polarizer the plates and aperture are put as shown in Fig. 4, in the other as shown in Fig. 5.

The images are projected through these in the ordinary way on to the screen, but, as stated above, will not coincide. The observer is provided with a lorgnette, which is also provided with analyzers, which are merely the bundles of glass, and these are placed in exactly the same way as the polarizers, as shown in Figs. 4 and 5, and the picture projected through the vertical polarizer Fig. 4 is viewed through the analyzer of same direction, and the same applies to the picture projected through Fig. 5.

The success of the working of the lantern was certainly striking, and this was not so good as it will be later on, because of the screen. It is a curious fact that nearly every substance that reflects light also polarizes it, except metals, and the consequence is that Mr. Anderton is obliged to use silver foil as a screen, and very well it acted. R. Field & Co., of Suffolk Street, Birmingham, are the makers of the lantern.—*Amateur Photographer.*

## PHOTOGRAPHY WITHOUT A CAMERA.

PHOTOGRAPHY offers numerous and ever new resources not only for the *utilis*, but also for the *dulcis*. We find in it an inexhaustible source of amusements, certain of which present an absolutely artistic character. Of these, we desire to give as an example, on the present occasion, only the following interesting experiments that we find in Messrs. Bergeret & Drouin's *Recreations Photographiques*. The reader will see therein how, without any apparatus, that is to say, without a camera, directly and with but a simple

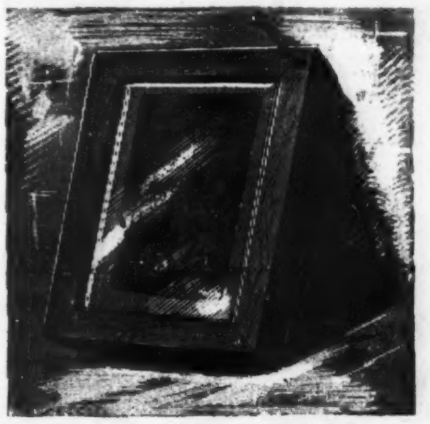


FIG. 1.

frame, it is possible to obtain charming prints, some of which might really find a place in the illustrations of botanical treatises.

Photography, say these authors, offers a wide field of recreation, even to the amateur who is not provided with a camera and objective. Thus, fabrics, laces, the leaves of trees and certain flowers can be reproduced by contact, the sole *materiel* necessary being a press frame.

For all such reproductions, one contents himself ordinarily with a negative which gives in white upon a black ground the object to be reproduced.

For the reproduction of laces, it is necessary, if they have a certain thickness, to operate in open sunlight, and to hold the frame exactly at right angles with the luminous rays. This result may be easily obtained by sticking a pin, E, into the frame as shown in Fig. 1, and in so holding the frame in the hand that the shadow of the head of the pin shall be projected exactly upon the point at which it is inserted.

As regards the reproductions of leaves, it is well, before putting the latter in contact with the sensitized paper, to expose them to the sun in the frame for half an hour, in covering them with several thicknesses of blotting paper, so that they may dry sufficiently without altering the sensitized paper.

On employing ferro-prussiate paper, the manipulation of which is extremely simple and inexpensive, it is possible to make collections of leaves.

In Fig. 2 we give a reproduction of a raspberry leaf that presents a case of polymorphism, which is quite

FIG. 2.

frequent, and results from the cohesion of the upper leaflet with one of the lateral ones. The time of exposure naturally varies according to the transparency of the leaf, and the image should be attentively watched, so as to arrest it at the moment at which all the details have appeared.

For more convenience, the leaves are sometimes fixed to the glass of the frame. In the woods there are often found splendid specimens of skeleton leaves formed as a consequence of the slow decomposition of the epidermis. These skeletons form a delicate lacework which, in the press frame, gives very beautiful reproductions. It is possible, moreover, to obtain these skeletons of leaves artificially by one of the following processes: 1. First, strike the leaf, placed flat upon the knee, with a hair clothes brush. 2. Boil the leaves in a solution of an alkaline carbonate until the epidermis easily detaches itself, remove the latter with a small scalpel and then detach the parenchyma with the finger or a small brush in placing the leaf in water. Finally, dry the leaf between blotting paper.

It is possible, when the skeleton is prepared by the first process, to reserve letters or designs upon the leaf that have been cut out of paper and fixed with gum. The brush does not traverse these parts, which come out in white when the printing is done in the press frame. One can thus obtain varied effects, and employ photographs of leaves, vignettes, etc., as *motifs*.

In Fig. 3 we give a reproduction, by photogravure, of a slightly different style. The background of this has been printed by exposing an ivy leaf upon sensitized paper after preserving a blank space in the center of the leaf. The portrait was afterward printed as a vignette upon the portion remaining sensitized.—*Le Naturaliste.*

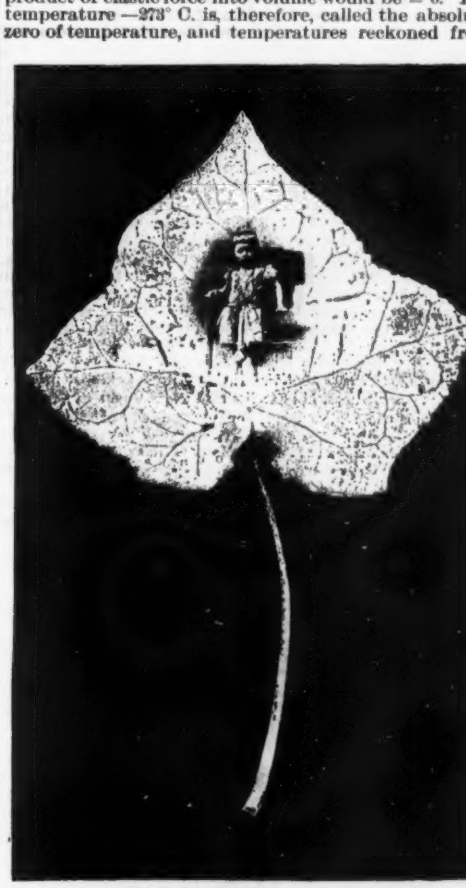


FIG. 3.

## THE "ABSOLUTE ZERO" SO CALLED.

By HENRY WURTZ, Ph.D.

THE term *absolute zero* has been in use in scientific writings and scientific parlance, and has been a factor in shaping investigation and in guiding the current of scientific thought for probably forty years past.

The term may have been introduced by Clausius or Rankine, and it may be that the original meaning was only to indicate the point of temperature at which all gaseous expansion disappears, according to the Boyle-Mariotte law, and not to signify a temperature at which all matter becomes destitute of the power to impart heat energy altogether; or in other words, a point at which matter is so cold that it cannot get any colder. Yet this latter is the sense in which the term is often applied in scientific writings. Thus Balfour Stewart (*Lessons in Elementary Physics*, p. 210) states that Clausius, Rankine and Thomson have shown that "the absolute zero" corresponds to "about −270 C. (518° F.), a point which denotes the absolute deprivation of all heat."

It appears from the context that the eminent investigators named presented this view in discussion of the theory of the steam engine; and, as above intimated, it is probably true that this temperature is that at which gaseous or vaporous expansion vanishes, which is all that concerns the steam engine.

In Watts' *Dictionary of Chemistry* (vol. 3, p. 52) is found the following: "It results from the fundamental formula (there given) of gaseous expansion

$$pv = J(a + t);$$

$v$ being the volume of the given weight of the gas at temperature $t$ and under pressure $p$; J and $a$ being constants—that, if the temperature of the gas were reduced until it became $= -a = -273°$ C. (523¼° F.), the gas would cease to have any gaseous elasticity—the product of elastic force into volume would be $= 0$. The temperature −273° C. is, therefore, called the absolute zero of temperature, and temperatures reckoned from it are called *absolute temperatures*. These are obviously obtained in any case by adding 273° C. to the number of degrees by which the temperature is expressed on the Centigrade scale; and by employing them in the expression of the laws regulating the relations between temperature and other properties, the resulting expressions are often much simpler than those required when temperatures are expressed according to any ordinary thermometric scale."

The latter part of this is rather vague. The fact that expressions are simplified by the adoption of the temperature of the lower limit of gaseous elasticity—

admitting that —273° C. is such—appears to be in itself no reason for calling this the "absolute zero," or the temperatures reckoned from it "absolute temperatures." These terms, except in so far as they apply to gaseous elasticity, are nothing but expressions of hypotheses, and the only term that is justifiable, in a truly scientific sense, is that —273° C. may be, and probably is, the zero of gaseous (and vaporous) elasticity. The present writer, sixteen years ago, in 1877, writing for *Johnson's Universal Cyclopedia* (vol. iv., p. 1547), demurred to this term, saying that he believed the "so-called absolute zero of temperature" to be "probably only that temperature at which the most incondensable of our *gaseous* bodies—doubtless hydrogen—would lose its gaseous form and become a liquid."

Since this date, *hydrogen*, *oxygen*, *air*, and other gases then as yet uncondensed, are stated to have at length yielded to improved methods, and given liquid condensed products. No reliable statement has, however, been met with by the writer as to the temperature at which this was effected in the case of hydrogen, or rather of the temperature of ebullition of liquid hydrogen.

But assuming that liquid hydrogen turns out to be the liquid that boils at the lowest temperature of all, and even assuming further that this temperature turns out to be at or near —270 or —273° C., would this prove such temperature to be the "point which denotes the absolute deprivation of all heat"? Has not this liquid, like water and all other liquids, its latent heat of liquefaction? Further, suppose we deprive it of this latter, and get solid frozen hydrogen. Has not this in it yet all the potential heat energy that it evolves when it *burns*, after having received back again, in addition, its latent heat of fusion and its heat of gaseous elasticity? To the writer it appears that it would be quite as reasonable to say that if we start with vapor of paraffine wax and condense it to melted paraffine, we have reached the absolute zero. We have certainly reached the absolute zero of elasticity of the vapor of paraffine wax. If now we dip into the melted paraffine a piece of cold iron, the latter gets warm, receiving heat from the liquid, and the liquid itself chills and solidifies into paraffine wax, which has in it still all its heat-evolving potentiality, just as it had in the form of vapor at first; and, in point of fact, it is itself partly solid hydrogen. Would any one deny the possibility, if we had attained to perfect command of nature, of dipping in like manner into liquefied hydrogen a body colder than itself, which would receive from it heat, chilling the hydrogen into a solid form?

The writer urges that this term, this misnomer, "absolute zero of heat," so much in vogue, should be altered to *absolute zero of gaseous elasticity*, and thus limited to its probable or possible actual significance.

## ANIMALS OF THE TCHAD.

IN his recent mission to the upper Oubanghi, Mr. Dybowski had an opportunity of observing a certain number of animals, a few of which we figure herewith.

One would be greatly deceived were he to believe that the forests of Congo are filled with the songs of birds. They are, for the most part, silent, and it is rare that the song of any little bird is heard during the day. It is only when night supervenes that noises are heard on every hand. These are due to great flocks of gray parrots that all alight upon the same tree, which serves them as a perching place for the night, and which they leave in the morning in quest of food in the fields, and also to horn-bills (Fig. 4), which take flight in uttering strident cries. At Lyranga one observes at night legions of large bats (Fig. 1), with a spread of wing of 32 inches, that gather a fig in their rapid flight and carry it off with them. Their evolution is so prompt that they do not stop, so to speak, and it is not a very easy thing to bring them down in their flight. During the day they all assemble upon some large tree which they have selected as a domicile and from the branches of which they suspend themselves.

The aborigines of the villages of Afourous take in abundance two animals which they hunt for as food. One of these is a small species of alligator and the other a water turtle from 16 to 20 inches in length, and of about the same width. In order to keep these alive for some time, the natives bore a hole in the edge of the carapax, pass a cord through it and attach them to a tree.

From the Gaboon to the Congo and from the Congo to the upper Nile, the buffalo seems to be widely dis-

FIG. 1.—AFRICAN BATS.
(*Hypsignathus monstruosus.*)

tributed, and, notwithstanding the immense area that it occupies, the species is everywhere uniform. It is the same buffalo (Fig. 5) that is domesticated at the Cape. The hunting of it is extremely dangerous. When it is attacked, it almost always turns upon its pursuer, and, if it is not arrested in its onset, will follow its aggressor with fury. The hunting is often followed by the death of those engaged in it

A small species of antelope (Fig. 2) not exceeding 20 inches in height at the withers, and of a mouse color, is common near Bangui. There are also phalangers (Fig. 3) met with here that are very rare in Congo. During the day, these animals remain suspended by their four limbs beneath a branch with which their gray coat confounds them and consequently renders them difficult to discover. They do not begin to move until twilight, and even then their motions are slow. At intervals they utter shrill cries, move slowly along the branches, and then suddenly take flight, sometimes to a distance of more than five hundred feet, to the summit of some large tree.

Upon the river Kemo there are some interesting animals to be procured, and, among others, specimens of potamogales with a tale extremely wide at the base. These animals seem to exist in all the rivers of Gaboon and Congo. But there are everywhere rare animals difficult to capture, and are therefore scarcely represented in European museums. It should be remarked that the zoological or botanical species that live on the banks of the watercourses have a much wider geographical range than those that are found inland.—*La Science Moderne.*

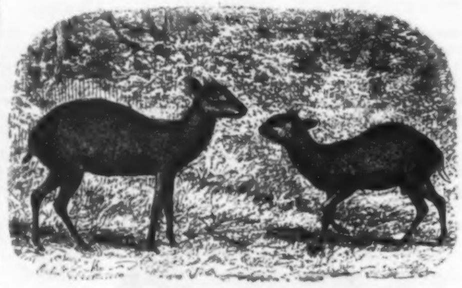


FIG. 2.—SMALL ANTELOPES.
(*Cephalophus melanorheus.*)

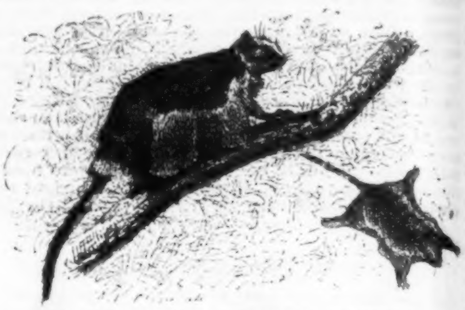


FIG. 3.—PHALANGERS OF BANGUI.
(*Anomalurus erythonothus.*)

FIG. 4.—HORN-BILLS OF VARIOUS SPECIES.

FIG. 5.—WILD BUFFALO AND OX.

## SWORDFISH EXPLOITS.

SEVERAL years ago we published an account of a couple of men out in a boat, fishing in the lower New York bay, who observed a commotion among a shoal of small fish, and rowing to the spot, found what they at first supposed, by its single fin above the water, to be a shark. They attacked the monster with a view of capture, and were astonished by the sudden piercing through of their boat bottom by the sword, 4½ feet long, of a large swordfish. They succeeded in noosing his tail, securing and killing the fish, after which he was towed ashore, and subsequently brought up to the city to a restaurant in Park Row, a few doors from the SCIENTIFIC AMERICAN office. The fish weighed 300 pounds and measured 19 feet 8 inches in extreme length. It was certainly one of the finest specimens we ever saw.

The Liverpool *Mercury* gave a report from Captain Harwood, of the brigantine Fortunate from Rio Grande, to the effect that the vessel, while at sea was struck and shaken by a swordfish. After discharging the cargo at Liverpool the hull was examined and the sword of the fish found, broken off even with the outside planking. The fish had driven his sword completely through the four inch planking, leaving eight inches of the blade projecting within the vessel.

The swordfish is allied to the mackerel, which it resembles in form, and is a swift swimmer. The sword is a most formidable blade, consisting of a strong, straight bone, sharp and flat, projecting horizontally from the nose, of which it is a prolongation.

The swordfish is found in considerable numbers off the island of Martha's Vineyard, coast of Massachusetts, at this season of the year. Its flesh is considered excellent food by many persons, and the annual catch is quite large. The ordinary length of the body of the fish at full growth is 14 feet, and its sword 6 feet, or 20 feet in all.

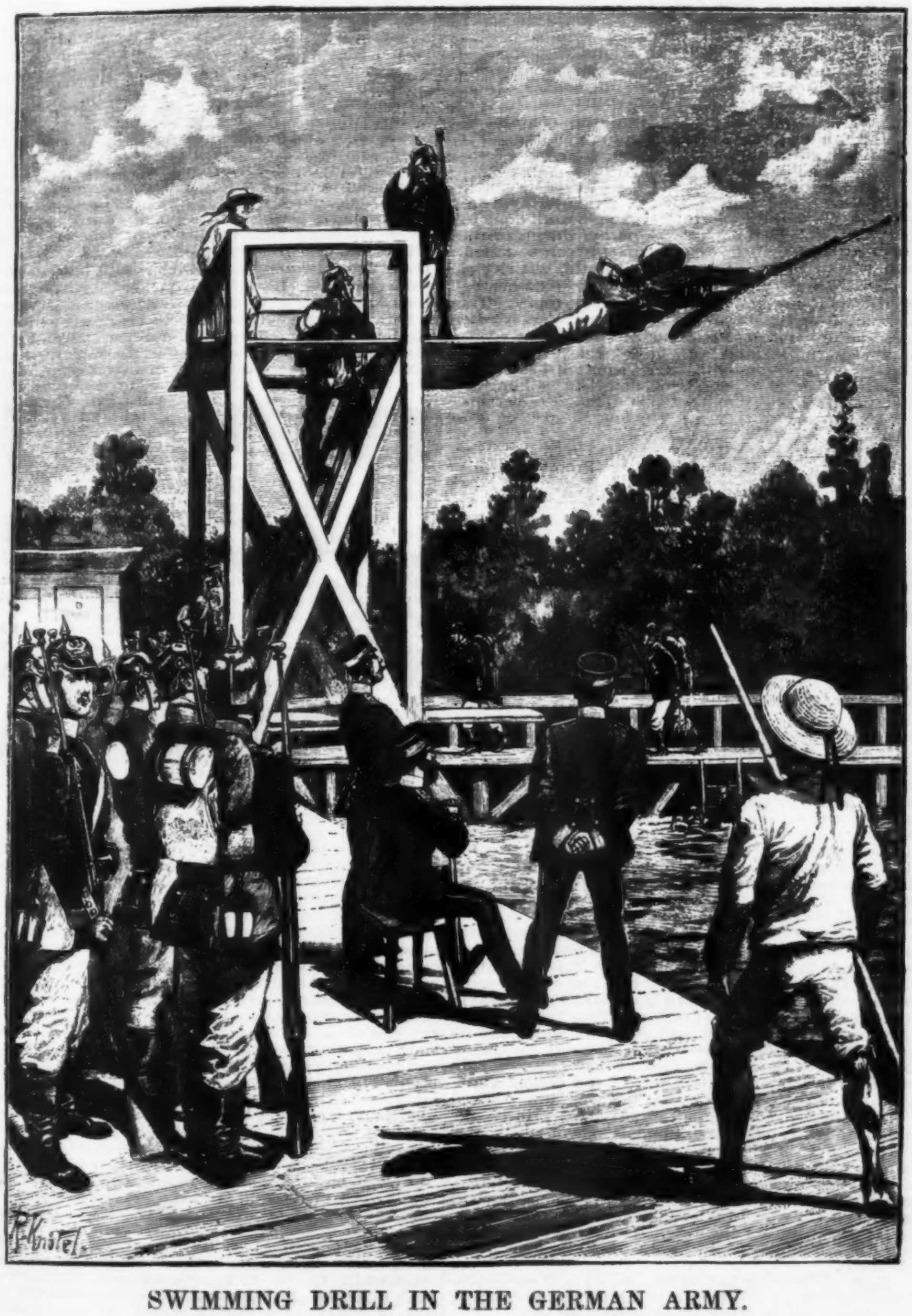
Swordfish have been unusually plentiful off this coast last summer. The fishermen hunt them with harpoons, spearing them from the decks of small sail vessels. In July last the fishing smack Mattie and Lena arrived at Stonington, Conn., after a four days' trip about Block Island, with sixteen large swordfish,

A SWORDFISH PIERCES A BOAT.

averaging 300 pounds each, and an exciting story of a struggle for life between Henry Cheesebro, one of the crew, and a wounded and maddened swordfish.

Cheesebro had harpooned a big fish off Montauk Point, and, after waiting the usual length of time, got into a small boat to bring the apparently exhausted fish to the vessel. As soon as Cheesebro approached him and commenced hauling in the line the fish awoke from his torpor and started to battle for his life. He began operations by diving so as to spear Cheesebro's boat on coming to the surface. Missing his aim, the fish dived again for a second attack.

It was now too late for Cheesebro to retreat, and defenseless, in the frail cedar yawl, he awaited the onslaught. He was kept in suspense but a moment. When the fish shot out of the water once more, he drove his sword completely through the boat from side to side. The sword entered the boat about three feet from the bow, on the port side, and came out through the thin plank on the starboard side. Cheesebro had retreated to the stern of the boat in time to avoid the violence of the fierce fish, and thus escaped injury.



SWIMMING DRILL IN THE GERMAN ARMY.

His plight was seen from the schooner, and the vessel headed for the scene of the conflict. By constant baling Cheesebro kept his frail and disabled craft afloat until succor arrived. A blow on the head finally killed the fish, and Cheesebro's peril as a sword fisherman was over for this time. The fish weighed 338 pounds.

## SWIMMING DRILL IN THE GERMAN ARMY.

FROM the time of Frederick the Great drill has always been the strong point of the Prussian army; and since the union of German-speaking states the armies of the various kingdoms and principalities which form the empire now ruled by William II. have advanced by rapid strides, until it is beyond doubt that for perfection of drill they are unsurpassed by any troops in the world. The work which this state of perfection entails on the individual soldier is very great. Every private has his copiously illustrated "Drill Book," teaching him the theory of all the steps and exercises, the practice of which he acquires under tuition on the exercise place and in the gymnasium for several hours each morning. And however ridiculous and useless some of the exercises appear to our eyes, the German soldier undergoes them cheerfully and uncomplainingly.

One of the most useful, as it certainly is one of the most interesting, of all the exercises in the German army is the swimming and diving drill as it is practiced at the military swimming baths during the summer months. It is compulsory only on the pioneers, but privates of all arms are encouraged to practice it by small money prizes and prospective promotion. The diving from a considerable height, as shown in the drawing, is best worth watching. The men taking part in it are clothed in uniforms of the oldest and least valuable description, and accoutered with "dummy" kits of precisely similar size and weight to their ordinary equipments. They are furnished with model guns and bayonets of wood, the points of the latter terminating, as may be seen, in wooden knobs. Under the direction of the military swimming master the men mount the steps leading to the diving platform in rotation, and at the word of command each takes "a header down below" precisely as is shown in our illustration, however much it is apparently opposed to English professional ideas of diving from a height.

After a more or less prolonged interval, the pioneer private "bobs up serenely," and generally (contrary to the expectation of the uninitiated stranger), without having lost his helmet or rifle and without having disarranged his accouterments, strikes out across the bath for the landing stage. The pioneers are also instructed in the towing of piles, stakes, balks of timber, and trunks of trees into position for bridge construction.

The supreme usefulness of this form of drill is very evident, and it would be well for us if our own engineers were systematically practiced in similar operations. But perhaps it would be more reasonable to expect that the seamen and marines of our fleet should be taught to swim before we demand that our army should be instructed in the accomplishment of what, we fear, many of our military authorities would be inclined to term "fancy feats." We give an illustration which will convey some impression of the manner in which this kind of drill is performed.

## THE GEOLOGICAL SOCIETY OF AMERICA.

By E. O. HOVEY.

THE sixth annual meeting of the Geological Society of America was called to order in the lecture room of the Boston Society of Natural History, Wednesday morning, December 27, by the president, Sir J. William Dawson, of Montreal. In the address of welcome by Professor W. H. Niles, president of the Boston Society of Natural History, attention was called to the comparatively great age of the Boston society. This association of naturalists is now nearing the close of the sixty-fourth year of its continuous existence, and has risen from a position of insignificance to one of great influence. A half century ago, or thereabout, it was considered a bold thing to bring Sir Charles Lyell to Boston to lecture, and that eminent geologist was mocked in the comic theaters, and the society was denounced by persons of standing. Orthodox people feared that geologists would seek to overthrow Christianity. To-day between 600 and 700 students of field geology are connected with the society annually, besides those who patronize the special lectures on the museum collection, and the large number of teachers and others who attend the regular course of lectures on geology and take a rigid examination thereon. This old society very gladly and heartily welcomed as its guest the strong though very youthful Geological Society of America, which is now only beginning its sixth year.

The programme presented to the fellows was remarkable for the number, variety and importance of the papers it contained. Fifty-nine treatises were submitted, of which forty-five were read, the remainder, for various reasons, being read by title only. The subjects treated were scattered pretty well over the whole field of geology, from Lower Laurentian gneisses to Pleistocene gravels, and discussed the matter from various standpoints, stratigraphic, paleontologic, historic and petrographic. Questions of economic importance as well as those of pure theory received careful consideration.

The reports of the secretary and the treasurer show the excellent condition of the society in every way. During the last year, fortunately, no fellows have been lost by death. The latest printed roll of membership contains the names of 283 living and nine deceased fellows. Since the issuing of this roll nine men have been received and two have resigned, while six have been dropped for continued delinquence in the payment of dues. The net membership at present, therefore, is 284. Fourteen nominations are now awaiting action by the council of administration. The treasurer received $3,859 and disbursed $3,226 during the year.

Among so many excellent papers and discussions it is hard to select what shall be presented in a brief report like the present—all were of interest and value.

The presidential address of Sir J. William Dawson was on "Some Recent Discussions in Geology," and treated in its distinguished author's most happy style theories which are now receiving the active attention of geologists throughout the world regarding continent making and mountain building. He impressed upon the society the thought that geology is a science in which it is especially true that "the goal of to-day is the starting point of to-morrow." Professor Dawson noted first the controversies respecting the age of the older crystalline rocks, the true foundation stones of continents, and stated that the basal rocks wherever found closely resemble the gneisses of the Lower Laurentian age, which attain their greatest development in Canada. These gneisses form the nucleus around which the continents have been built up.

Referring to mountain building, he said that it was necessary to specify in advance the kind of mountain under discussion. The author noted three kinds:

1. *Dump mountains* are those like Vesuvius, Cotopaxi and other volcanoes, ancient and modern, the materials of which have been brought up from below and dumped down on top.

2. *Blister mountains* rise by gentle slope without much disturbance, to considerable height, like Mount Lebanon in Syria and the Sierra Nevada in this country. Igneous ejections of later date are associated with these as a result, not cause.

3. *Crumpled mountains* show much distortion and disruption of strata. The Cordilleran mountains of the West, Appalachians, the Alps, etc., are examples of this kind. Some chains show all three kinds.

Physicists insist on a hard, rigid globe, but geology shows that the earth's crust has moved and does move. Prof. Dawson has great respect for the time-honored contraction theory, as explained by Le Conte. The expansion theory of Mellard Reade is not antagonistic to the contraction theory, but really assists it by furnishing additional force for the elevation of mountains and continents. The isostatic or flotation theory also, as propounded by Dutton, has its place. "When it is necessary to compress vast masses of rock into one-third their normal horizontal dimensions and elevate them thousands of feet above the level at which they were deposited, we may be glad to invoke the aid of all these theoretic forces and others besides."

Turning his attention to the advocates of uniformitarianism on one hand and of catastrophism on the other, as explaining the succession of strata and life in geologic history, he said that, as usual, the truth lay between the extremes. The same natural laws have prevailed from the earliest Laurentian to the present, but they have had to deal with the continents in very different stages of development, and, therefore, have produced very different results at successive periods. Furthermore, a catastrophe is often merely the culmination of slowly acting forces and is truly a part of the uniformity of nature. The slow crumbling of the face of a cliff is very gradual, but it leads to the sudden fall of vast masses of rock, exposing again new surfaces to infinitely slow decay.

Animals and plants of the abysses of the oceans are the only things which have not suffered from vicissitudes and have undergone only gradual changes. Those of shallower and littoral waters have advanced, retreated, and changed as the continents have risen or sunk. A matter of much interest in connection with paleo-botany is the evidence afforded by fossil plants as to the changes of climate and the underlying causes thereof. He showed by many illustrations how much

light fossil plants are capable of throwing on these questions and how strongly they support the idea that the vicissitudes of climate in geologic time were mainly due to the varying distribution of land and water. The areas of land and water, however, were sufficiently stable to support a continuous succession of animal and vegetable life.

The ice of the great glacial epoch was local rather than general, and there is strong evidence to show the existence of an open polar sea during the period. Prof. Dawson thinks it necessary to abandon the attempt to account for all the phenomena of the epoch by land ice alone, and that we must utilize seaborne ice as well as glaciers. According to the best authorities, the great ice age closed but 10,000 years ago. This and other arguments suggest that vast movements of the earth's crust have taken place in periods geologically recent. The author has long advocated the probability of a great diluvial catastrophe since the advent of man on the earth, on the evidence of the extension of the northern continents in the early human period and the apparently sudden destruction of man and many of the larger animals of the Palanthropic age producing a break in life between this and succeeding ages. "This conclusion," said he, "seems now triumphant, and is beginning to bring the geological events of the later tertiary into harmonious connection with the history of early man as deduced from traditions and records."

In another paper read before the society Sir J. W. Dawson described in detail some new discoveries in the famous upright trunks of tree ferns (Sigillariæ) in the coal measure sandstone at the South Joggins, Nova Scotia. A forest or grove of these large ribbed trees was either submerged by subsidence or, growing on low ground, was invaded by the muddy waters of an inundation, or successive inundations, so that the trunks were buried to the depth of several feet. The projecting tops having been removed by sub-aerial decay, the buried stumps became hollow, the hard outer bark remaining intact. Thus they became hollow cylinders in a vertical position and open at top. The surface having then become dry land covered with vegetation, was haunted by small quadrupeds and other land animals, which from time to time fell into the open holes, in some cases nine feet deep, and could not extricate themselves. On their death and the decomposition of their soft parts, their bones and other hard portions remained in the bottom of the tree intermixed with any vegetable debris or soil washed in by rain, which formed thin layers separating successive animal deposits from each other. Finally, the area was again submerged or overflowed by water bearing sand and mud. The hollow trees were filled to the top and their animal contents thus sealed up. At length the material filling the trees was by pressure and the access of cementing matter hardened into stone, not infrequently harder than that of the containing beds. The whole being tilted to an angle of 20° and elevated into land exposed to the action of the tides and waves, these singular coffins present themselves as stony cylinders projecting from the cliff or reef and can be extracted and their contents studied. Thirty such trees have been found at the South Joggins, but none have been reported from anywhere else in the world. About fifteen of these have produced animal remains, showing the existence in the Carboniferous age of land reptiles, batrachians, land snails, millipedes, and insects.

A relatively large number of petrographic papers occupied most of the attention of the society during its one day session at Harvard, Thursday. The most important of these was by Prof. George H. Williams, of Johns Hopkins University, Baltimore, on "Ancient volcanic rocks along the eastern border of North America." The occurrence of ancient volcanic rocks at various horizons along the Appalachian belt has long been recognized by some American geologists. Prof. Williams not only summarized and co-ordinated all pre-existing information on the subject, but also directed attention to many newly discovered areas of these rocks, most of which had been entirely misinterpreted by early geologists. The term volcanic should be confined to igneous rocks which consolidated at the surface which existed at the time of their extravasation. Certain criteria were given for distinguishing volcanic from non-volcanic igneous rocks, the most important of which was the association with volcanic tuff. German and other continental petrographers draw a sharp line of distinction at the beginning of the tertiary era between paleo and neo volcanic rocks, thus giving different names to rocks of the same mineral and chemical composition. English petrographers, on the other hand, rightly contend that mere difference of age should not cause us to give different names to the same kind of igneous rock. American geologists are not committed by early literature to artificial distinctions, and can and ought to make terms which describe things accurately or nearly so.

The result of Prof. Williams' personal observations and his correlation of the work of others is to establish two zones of ancient volcanoes in eastern North America. These zones roughly approximate parallelism, one along the seacoast and one along the mountains. The outer belt has been recognized in eastern Newfoundland, Cape Breton Is., along the Maine coast at Eastport, Vinal Haven and Machiasport, then in the Boston Basin and in Rhode Island. The inner and mountainous belt has been traced from Gaspe Bay through the Eastern provinces to northern Vermont, then from Harrisburg in a fine series for 150 miles to Peach Mountain, Va. A belt of ancient volcanics twelve miles wide traverses the State of North Carolina, near Raleigh, and extends into South Carolina. Prof. Williams' paper was illustrated by an interesting series of specimens of ancient (*i. e.*, pretertiary) basaltic and pumice stone from Maryland.

Prof. G. K. Gilbert, of the United States Geological Survey, gave some deductions regarding the derivation of sedimentary from igneous rocks based on the following table, which was prepared by Prof. F. W. Clark by comparing 800 analyses of igneous rocks from all over the world and obtaining the averages:

| | | | |
|---|---|---|---|
| Oxygen | 47·3 | Magnesium | 2·7 |
| Silicon | 27·2 | Potassium | 2·4 |
| Aluminum | 7·8 | Sodium | 2·4 |
| Iron | 5·5 | | |
| Calcium | 3·8 | | 99·0 |

Now the proportion of the different sedimentary rocks to one another may be roughly represented thus:

| | |
|---|---|
| Sandstone | 39 |
| Shales | 42 |
| Limestone | 19 |
| | 100 |

The oxygen of the igneous rocks is found in all the sedimentaries; the silicon mostly in the sandstones; the aluminum mostly in shales and clays; the iron in all; the calcium and magnesium mostly in the limestones; the potassium probably in the shales for the most part. Sodium is scarcely found in rocks, except as beds of salt and brines, and it is most probable that the ocean has received the largest part of the sodium set free by the decomposition of the igneous rocks. It has been calculated that there is enough sodium in the waters of the ocean to form a layer about 350 ft. thick over the surface of the land, indicating the erosion and decomposition of a sheet of rock rather more than a mile in thickness.

The point of most general interest in the paper by Prof. J. F. Kemp, of Columbia School of Mines, on the "Gabbros of the western shore of Lake Champlain," was the relation of these rocks to the Adirondack iron ores. Gabbro is a coarse-grained igneous rock somewhat resembling granite in appearance, but consisting essentially of lime-soda feldspar (labradorite) and the pyroxene known as diallage. This rock is intrusive into the limestones and schists of the Adirondack region, and carries great beds, sometimes twenty feet thick, of magnetic iron ore. This ore, however, contains so much titanium as to be worthless for smelting. The valuable non-titaniferous magnetic iron ore of the region is found in the gneisses.

In a paper on the geology of Coosa Valley, in northern Alabama and Georgia, Dr. C. Willard Hayes described some of the important economic work done by the U. S. Geological Survey in a part of the great iron producing region of the South. Iron ore can be raised, washed and delivered on the cars in this district at a cost of 90 cents per ton. The area described lies between the Rome and Cartersville thrust faults. The rocks are from Cambrian to Carboniferous inclusive in age, and present interesting stratigraphic problems in unconformities and wide lithologic variations in contemporaneous deposits. The structure has resulted from two or more periods of mountain building activity, in which the forces acted in different directions, and probably were separated by long periods of erosion.

Wednesday evening the society had a treat in the shape of a detailed description by Prof. Alexander Agassiz of an exploring trip to the Bahama Islands. These islands are typical atolls, but are not built up by coral animals from great depths, but rest on heavy limestone beds of other origin. There has been a subsidence in the region of about 150 ft., which has been made good by the growth of the corals. All the elevated portions of the islands were found to be formed of coral sand, blown up from the beach by the winds. These Æolian hills rise to the height of 350 ft. on Cat Island. The process of formation is very simple. At low tide the wind drives fragments of corals up the beach, forming dunes of sand, which the winds from N. E., S. and N. make into three series and then consolidate into simpler hills. Water percolating through the sand dissolves a part and redeposits the carbonate of lime as a cement for the rest, forming a more or less solid rock. This rock is sawn out of the quarries and used to a considerable extent for building, as it hardens on exposure to the air. There are from 600 to 650 islands in the group. The major portion of the area is taken up by great shallow banks which are indented on the east side by deep tongues of the ocean. The northern or Little Bahama bank nowhere shows a depth of more than eleven fathoms, while the Great Bahama bank is only six to seven fathoms below the surface, except at the extreme southern end, where the depth increases to nineteen fathoms.

Echoes of the discussion over the glacial period inherited from the Rochester and Madison meetings were heard in the papers by Professor T. C. Chamberlin, of Chicago, and Professor G. F. Wright on the same region, viz., the northwestern portion of Pennsylvania and the adjoining parts of Ohio and New York, with regard to the past drainage systems of the region and its glacial history. The investigations of Professor Chamberlin and his assistant, Professor Frank Leverett, substantiate the statements of Carll, of the earlier Pennsylvania geological survey, that the area now drained by the Allegheny River discharged its waters into Lake Erie through two or three channels, one of which was through French Creek and one from the Ohio River through Beaver Creek into the lake. Professor Wright claims that the rock channels of the Allegheny, Monongahela and Ohio Rivers were eroded before the first glacial epoch, which would indicate that these rivers never flowed into Lake Erie. The mooted questions are still the subject of field work which may soon settle them.

Many of the other papers read might well receive notice here, but all will appear in full in the *Bulletin* of the society and in other scientific publications.

The social side of the convention was not entirely overlooked amid so much serious business and the discussion of such knotty problems. Wednesday evening, after Professor Agassiz's lecture, the ladies connected with the Boston Society of Natural History gave an informal reception in the library rooms of the institution. Thursday afternoon, after the sessions at Harvard, President and Mrs. Eliot gave a tea. Thursday evening, at the Thorndike Hotel, the society had its annual dinner. Thirty-nine fellows participated in the dinner. As showing the tendency of American students, it is interesting to note that eleven of this number had studied petrography under Professor Rosenbusch at Heidelberg.

Late Friday evening the largest and most successful annual meeting which the Geological Society of America has held came to a close, after giving its hosts an enthusiastic vote of thanks. About seventy-five fellows, besides many visitors, were in attendance. W. J. McGee, of the United States Geological Survey, was elevated to life membership in recognition of his services to the society as editor. The following officers were elected for 1894: President, T. C. Chamberlin, Chicago; first vice-president, N. S. Shaler, Cambridge; second vice-president, G. H. Williams, Baltimore; secretary, H. L. Fairchild, Rochester; treasurer, I. C. White, Morgantown; editor, Joseph Stanley-Brown, Washington. The last three incumbents held the same offices last year.

## POLYPODIUMS.

AMONG the ferns most valuable for decoration, Polypodiums occupy a prominent position. The genus is very extensive and comprises plants of small, medium, and large dimensions, adapted either for growing in suspended baskets, for pot culture, for planting out in the open-air fernery, or as edgings for the rock garden. The geographical distribution of the genus is such that it may safely be said that Polypodiums of one section or another are found in nearly every part of the globe. Besides the common Polypody (P. vulgare), which makes for itself a congenial home in the mossy bark of old trees or on the tops and in the crevices of old walls, or which we find clothing the sloping sides of our hedge banks, where it frequently forms a dense mass of undergrowth among the roots of the hedges themselves, the most remarkable species native of Great Britain are the oak fern (P. Dryopteris), the beech fern (P. Phegopteris), and the Limestone Polypody (P. calcareum or Robertianum), all well known to fern lovers. But even these species, although indigenous to this country, are of a very cosmopolitan character, the range of their habitat extending to North America and Japan.

There are a few species native of Australia and a few native of Japan, while a certain number of very distinct species are found throughout India, and a few others are native of the United States of North America and Canada. It is in Central and South America, however, that Polypodiums are most abundant and also most varied in form and in the texture of their fronds. An idea of the importance of the genus may be gathered from the fact that Nicholson, in his "Dictionary of Gardening," vol. iii., p. 186, states that "the genus Polypodium comprises upward of 400 species," and also from the numerous subdivisions to which it has been subjected by various authors. There are still a dozen of these subgenera retained by Hooker and Baker in their "Synopsis Filicum," all of which are distinguished from each other by their mode of venation or of fructification. These are Campyloneuron, Cyrtomiphlebium, Dictyopteris, Dipteris, Drynaria, Goniophlebium, Goniopteris, Grammitis, Niphobolus, Phegopteris, Phlebodium, and Phymatodes. All the foregoing, and more than forty other names which have now become obsolete, are Polypodiums, inasmuch as they have round or roundish sori (spore masses), which are naked or without indusium or covering, and composed of sporangia (spore cases) with an incomplete vertical ring.

POLYPODIUM NIGRESCENS.

With few exceptions Polypodiums are provided with rhizomes or decumbent stems from which their fronds are produced. In some species the fronds have their stalk adhering to and continuous with the rhizome, and are of an evergreen nature; but by far the greater number of Polypodiums have their frond stalks articulated to the rhizomes and are either wholly deciduous, like our own oak and beech ferns, or partly so, like our common Polypody, the beautifully purple-veined P. appendiculatum and the deservedly popular P. aureum and P. nigrescens, the former of which is illustrated in *The Garden* of February 21, 1885, while the latter forms the subject of our illustration. Polypodium nigrescens, native of Samoa, Fiji, and the Malay Islands, is also found in several localities in Southern India. It is a strong-growing species of very distinct appearance, interesting through the very conspicuous and ornamental nature of its spore masses, which, being sunk in a deep cavity, are prominent on the upper surface, a character which is shared by several other species of robust growth, principally P. subauriculatum and P. verrucosum.

All these and other kindred species thrive in a minimum temperature of 55° in winter, and in a lofty structure, where room can be afforded, nothing can be more beautiful than a hanging basket of P. subauriculatum. Speaking of this handsome species, native of Malaysia and the Philippine Islands, Schneider, in his "Book of Choice Ferns," vol. iii., p. 220, states that "in the center of a warm conservatory it surpasses all other ferns in elegance, and where there is plenty of height to allow the fronds space to hang, a specimen with numerous fronds each 10 feet to 12 feet long is a sight not easily forgotten." The same author also indicates another use for this plant when he says: "This fern can with great advantage be utilized for covering dead trunks of tree ferns; in such positions it makes a very beautiful object and grows apace, as it delights in sending its roots and rhizomes into partly decayed vegetable matter."

Among the strong-growing kinds of either erect or semi-drooping habit which show themselves to greater advantage by being planted out in the rockery I may

mention the glaucous P. aureum and its variety sporadocarpum, Billardieri, fraxinifolium, heracleum, iridioides, musæfolium, ornatum, Phyllitidis, subpetiolatum, etc. Among the species of medium growth particularly attractive through either the singular shape or the pleasing nature of their foliage, the most distinct are P. angustatum, appendiculatum, chnoodes, drepanum, fossum, heteractis, lingua and its crested and contorted form corymbiferum, Meyenianum, platyphyllum, vulgare cambricum, elegantissimum, and pulcherrimum, and also the very singular P. xiphias.

Of the dwarf-growing Polypodiums best known in gardens, the most useful and attractive are P. accedens, acrostichoides, adnescens, alpestre flexile, Dryopteris, hexagonopterum, glaucophyllum, lycopodioides and its variety salicifolium, piloselloides, Phegopteris, reptans, rupester, tricuspe, stigmaticum vaccinifolium, and the beautifully marked venosum, most of which make very handsome objects when grown on a pyramid of turfy peat.

A small number of Polypodiums, such as our oak and beech ferns, are provided with rhizomes of a slender nature, which delight in running underground in partly decayed vegetable matter, but in the majority of cases the rhizomes of either a fleshy or of a woody nature prefer being kept above or close to the ground, to which they have the faculty of adhering very firmly. The Polypodiums best adapted for pot culture are those in which the fronds are produced from a central crown; although those provided with underground rhizomes may be managed equally well in pots or planted, according to their native habitats, either in the stove, cool rockery, or outdoor fernery. The soil which suits these best is a compost of one part leaf mould or fibrous peat, two parts fibrous loam and one part silver sand.

For those species which are provided with rhizomes of a more or less woody nature, which keep near or even on the surface of the soil, a material of a different nature is required, and they have been observed to grow more luxuriantly in a mixture in which good fibrous peat or half-decayed leaf mould predominates and with a small portion of fibrous loam. In their case no silver sand is required. The propagation of the species provided with rhizomes may take place almost at any time of the year by division, while the others are most rapidly increased by means of spores, which in the majority of cases germinate freely when sown in heat and soon after they are ripe. It is worthy of notice that the plants raised from seed are usually of better shape than those of the same species produced by division of the rhizomes.—*The Garden.*

## ALLOYS.[1]

By Prof. W. CHANDLER ROBERTS-AUSTEN, C.B., F.R.S.

*Lectures I. and II.*

THE following pages will form the third series of Cantor Lectures which it has been my good fortune to deliver before this Society. In the first,[2] the "Alloys used for Coinage" were dealt with, while in the second,[3] an attempt was made to collect into as concise a form as possible the main facts connected with the history of our knowledge of the constitution of alloys, and with certain of their industrial applications.

It may be well to devote the present lectures to a consideration of the investigations to which alloys have been subjected during the five years which have passed since the last course was delivered, and it may at once be stated that the progress has not been inconsiderable. This progress is chiefly manifest in two directions. First, much light has been thrown on the particular grouping of associated metals; and, second, new alloys, new associations of metals that is, have been discovered which possess great scientific interest as well as industrial value. In no way has the advance been more marked than in the successful attempts of investigators to connect the behavior of alloys with ordinary compounds and solutions, more particularly with the solutions of salts, and the success which has been attained may be mainly attributed to the improvements in methods of measuring the high temperatures which are usually required to effect the solution of metals in each other. The whole question of the molecular constitution of alloys is intimately connected with our possession of means for investigating their thermal behavior during the passage from the molten to the solid state, from the solid to the liquid, and, finally, to metallic vapor. A brief description of the various appliances which can be used in such investigations may, therefore, well be given here, because the gradual development of pyrometry is intimately connected with the history of alloys, and, conversely, alloys have rendered great service in pyrometry. Attention will, however, be limited to the consideration of those forms of appliance which have either marked distinct stages of advance or have actually remained in use—it may be with much more or less modification—for the purposes of research.

The earliest pyrometers were essentially thermoscopes, and although their graduation presented great difficulties, the importance of being able to measure high temperatures has been recognized for centuries, and it would be difficult to illustrate this better than by a brief record of the testimony which has from time to time been offered by those who have had to apply the heat of furnaces in research or in industry; and it is mainly for the sake of the light incidentally thrown on the progress of research that the following historical notes are offered.

In the eighth century Geber, the chemist, wrote a treatise on furnaces, and showed that he was familiar with the means of applying heat; but he points to the difficulties that are met with in conducting operations at high temperatures, and these he attributed to inability to measure heat, his actual words being, "*sed quoniam non est res ignis, quæ mensuari possit.*"[4]

[1] Lectures delivered before the Society of Arts, London, 1893. From the Journal of the Society.

[2] *Journal*, No. 1,651, 1884.

[3] No. 1,873, 1888.

[4] From the edition of his works, "Summa Perfectionis Magisterii," published in Venice 1542, p. 28. There is some doubt whether in medieval translations additions have not been made to Geber's text.

The date of the invention of the ordinary thermometer is not well fixed; the conception of the instrument being variously attributed to Drebbel, Santorio and Flud; but I gather from a delightful article lent me by my friend, Prof. S. P. Thompson,[1] whose authority in connection with the early history of science is beyond question, that the claims of Santorio[2] are supported by Borelli[3] and Malpighi,[4] while the title of Drebbel is considered as undoubted by Boerhaave[5] and Musschenbroek.[6] Flud repeatedly draws the common air thermometer in his singular work,[7] "De Philosophia Moysiaca."

The earliest air thermometer I can find with a movable index is described by Robert Boyle, and consists of the ordinary glass bulb with a slender stem, in which a globule of mercury moves with the expansion or contraction of the air in the bulb.

In Waller's translation of the proceedings of the Academia del Cimento figures of many other ancient thermometers will be found.

The one here reproduced (Fig. 1) is perhaps the most

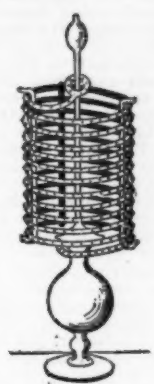


FIG. 1.

remarkable. Some readers of this may have shared with me the good fortune to have seen the actual instrument, which was exhibited in 1877 at the Loan Collection of Scientific Apparatus.[8] It consists of a lower bulb from which a long spiral proceeds and terminates in a smaller bulb at the upper end of the instrument. It is described in the account of the experiments made before the Academia del Cimento as being "of so exquisite a sense that the least flame of a candle" affects it.

I have elsewhere called attention[9] to the fact that Boyle alludes to Cornelius Drebbel as having invented "an automatous musical instrument and a furnace which he could regulate to any degree of heat by means of the same instrument."[10]

Space will, however, only permit me to refer to one instrument of singular interest from its relation to later appliances described in this paper. It is a recording thermometer, which appears to have been devised by Dr. Cummings,[11] of Chester, about the year 1803. It is shown in Fig. 2, in which $a$ represents

FIG. 2.

an air thermometer, and $b$ a barometer suspended from the opposite side of a wheel, $c$, to compensate the influence of variations in atmospheric pressure on the instrument; $d$, $d$, is a siphon cistern in both sides of which the mercury will always remain on the same level; $f$ is an index to which a pencil may be fixed for tracing the variations of the instrument on a plate revolving by means of clockwork.

I believe this to be the earliest instrument by the aid of which a time temperature diagram could have been traced. Mr. Kewley devised an instrument, patented in 1816, in which a differential mercurial thermometer was fixed to the beam of an ordinary balance.

[1] "Library of Useful Knowledge," article, "Thermometer and Pyrometer."

[2] Comment. in Galen. et in Avicen.

[3] "De Motu Animalium," prop. clxxv.

[4] "Opuscula Posth.," p. 30.

[5] "Elementa Chemiæ," tom 1, p. 152.

[6] "Elem. Phil. Nat.," section 780. Tentam Exp. Acad. Cim.

[7] "De Philosophia Moysiaca." Folio. Goudæ. 1638.

[8] See Catalogue of the Collection, No. 1838.

[9] "Proc. Roy. Institution," 1892.

[10] "Boyle's Works" (Shaw's edition), vol. iii., p. 38, 1738.

[11] "Library of Useful Knowledge," loc. cit., p. 46.

Hitherto thermometers[1] capable of measuring very moderate temperatures have alone been considered, and it is now necessary to turn to the consideration of true pyrometers, or instruments capable of indicating temperatures beyond the range of the ordinary mercurial thermometer. I have not found reference to earlier work than that of Sir Isaac Newton,[2] who, in 1701, applied his law of cooling to high temperatures, and in notes which accompany his *Scala graduum caloris* showed that he knew that the freezing point of lead differs slightly from its melting point.

Amontons made similar experiments in Paris at about the same time. Musschenbroek's pyrometer was constructed in 1731. He employed the expansion of a metallic rod for indicating the temperature to which the rod was raised. An early copy of his instrument was exhibited at the Loan Collection of Scientific Apparatus, 1877, and was, undoubtedly, one of the oldest of its kind.[3] Very many instruments of similar construction followed, but these must be passed over, as the principle on which they depend has practically been abandoned in accurate modern pyrometry. Reference must, however, be made to Josiah Wedgwood.[4] The measurement of the contraction of clay at high temperature was the basis on which his instrument rested, and, in communicating a description of it to the Royal Society, we find him, a thousand years after Geber had held that "fire cannot be measured," still lamenting the want of suitable instruments, saying, "How much it is to be wished that the authors (to whom he refers) had been able to convey to us a measure of the heat made use of in their valuable processes; . . . a red heat, a bright red and a white heat are," Wedgwood adds, "indeterminate expressions, and even though the three stages are sufficiently distinct from each other, they are of too great latitude, and pass into each other by numerous gradations which can neither be expressed in words nor discriminated by the eye."

Guyton Morveau (1808) saw the value of this appliance, and strove to reconcile the discrepancies which were discovered in working it. As regards date, the physicist who next deserves mention is Antoine Cesar Becquerel;[5] his contributions to electro-pyrometry were very noteworthy. In 1826 he used various thermo-couples, especially one of platinum and palladium, and he showed that even two wires of platinum of different manufacture could be employed. He actually measured, with the aid of a thermo-couple of fine wires, the temperatures of different portions of a luminous flame, and he fully recognized that when iron is used as one element of a thermo-couple, its behavior is abnormal. His couples were simply joined without solder.

Prinsep[6] was the first to use an air thermometer with a metallic bulb. He was the assay master of the mint at Benares, and appears to have been struck by the necessity for measuring variations in the temperature of the muffle used in assaying. He says, "the disparity of heat in different parts of the same muffle is greater than might have been supposed;" and, in view of the importance of the operation of assaying, he points out that "it would be useful to know every difference in this respect." Prinsep had already attempted to determine high temperatures by the use of a graduated series of alloys of gold and platinum—a method which is still in use—and he suggested the adoption of an optical pyrometer, in which the relative intensity of light from various sources was measured by interposing plates of brown mica between the eye and the glowing body.

In 1836 we come to Pouillet, whose work Barus, a distinguished authority on pyrometry, justly says is of prime importance. He constructed an air thermometer, with a bulb of platinum, which enabled him to work at very high temperatures. "He took the first definite step in radiation pyrometry by investigating the temperature at which solids glow; in calorimetric pyrometry, by determining the specific heat of platinum between 0° and 1,200°; and in thermo-electric pyrometry, by carefully calibrating a thermo-couple of platinum and iron."[7] In accepting this just tribute to Pouillet's work in thermo-electric pyrometry, we must not forget the earlier labors of A. C. Becquerel.

Pouillet's paper[8] is interesting reading, but it will be quoted here for the sake of its incidental references to practical work. He clearly shows that he suspected that gases are absorbed by platinum, and thus anticipates much later work; while, as regards the industrial value of the thermo-couple in pyrometry, he says: "This pyrometer offers the advantage of being a really practical instrument, and its sensibility augments as the temperature rises. When it is graduated by the air pyrometer, it is suitable for indicating, with great exactitude the temperature of any furnace, provided it is below the melting point of iron, that is, below the melting points of one of the elements of his couple." The facts stated in this sentence are, after a lapse of more than half a century, being generally accepted.

Joule[9] saw how useful the thermo-couple would be as an instrument of research, and actually employed a copper-iron one for measuring the heat which is evolved when a bar of metal is subjected to tensile stress. The early use of a thermo-couple for such a

[1] We are greatly influenced by heat and cold, and it is perhaps natural that the names of Celsius, of Fahrenheit, and of Reaumur, which are intimately connected with instruments for measuring variations of temperature, should be prominently remembered, even by unscientific persons, who have but little idea of the real nature of the work of these experimenters. In illustration of the fact that these names are household words, it may be worth while to quote the reply given by a youthful candidate to the question, "Describe any way in which the velocity of light has been measured." The answer, which Dr. Oliver Lodge ("Literary Blunders," by H. B. Wheatley, 1893, p. 185) assures us was actually given, was as follows: "A distinguished but heathen philosopher, Homer, was the first to discover this. He was standing one day at one side of the earth looking at Jupiter, when he conjectured that he would take sixteen minutes to get at the other side. This conjecture he then verified by careful experiment. Now the whole way across the earth is 3,072,000 miles, and dividing this by 16 we get 192,000 miles a second. . . . P. S.—I think the gentleman's name was Romer (Reaumur), not Homer; but any way, he was 20 per cent. wrong, and Mr. Fahrenheit and Mr. Celsius afterward made more careful computations."

[2] "Phil. Trans. Roy. Soc.," vol. xxii., p. 824.

[3] It was constructed after the description and drawing given on p. 12, table xxx. of Musschenbroek's "Tentamina Experimentorum Naturalium," Lugduni, 1731. Par. II.

[4] "Phil. Trans. Roy. Soc.," vol. lxxii., p. 305.

[5] "Ann. de Chim.," vol. xxxi., 1826, p. 371.

[6] "Phil. Trans. Roy. Soc.," 1828, p. 79.

[7] Barus, "United States Geological Survey." Bulletin 54, 1889.

[8] "Comptes Rendus," vol. 3, 1836, p. 782.

[9] "Phil. Trans.," vol. 149, 1859, p. 91.

purpose is so interesting that a sketch from Joule's paper is given in Fig. 3, and shows the way the thermocouple is inserted in the test piece. With reference to the use of iron in a couple it may be observed that Edmond Becquerel[1] appears to have been aware that

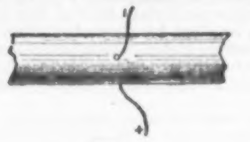


FIG. 3.

there was a critical point in iron, for he abandoned the use of the iron-platinum couple, because he found that the indications were disturbed between a temperature of 500° and 700°. We know now that one critical point in carburized iron does lie between these temperatures. He finally adopted the platinum-palladium couple, and his determinations of the melting points of silver (960°) and of gold (1092·2°) show less divergence than those of other experimenters from the figures now accepted.

Returning to Pouillet's work, it should be observed that the interdependence of the indications afforded by the air thermometer and by the thermo-couple is the basis of much work that followed. The air thermometer and the thermo-couple may really afford concurrent and equally trustworthy testimony in the measurement of high temperatures, but the difficulty of obtaining this testimony gave rise to the long controversies between E. Becquerel, who used the thermocouple, and Deville[2] and Troost, who advocated the adoption of the porcelain bulb air thermometer. The discussion concluded with the graceful words of the latter physicists.[3] "Nos nouvelles déterminations de la température d'ebullition du cadmium et du zinc, au moyen des thermomètre à air, sont presque concordantes avec les nombres qui ont été publiés par M. Edm. Becquerel, et cet accord avec ce savant physicien nous donne quelque confiance dans les expériences dont nous publions plus haut les résultats."

Let the reader study the classical work of Deville and Troost conducted with the air thermometer between the years 1863 and 1880, comparing it with the admirable researches of Edmond Becquerel, and then turn to a recent paper by Professor Barus[3] on "The calibration of the platinum, iridio-platinum, thermocouple,"[4] by the aid of a porcelain bulb air thermometer of refined and elaborate construction, and it will be evident how greatly scientific progress would have been promoted if the accuracy of the views of A. C. Becquerel and of Pouillet had been verified earlier. There was much intermediate work of great interest in this period, 1863-1880, of which space will not permit a detailed account to be given. It is, however, impossible to be indifferent to the scientific progress which was made in the early part of this critical period in the history of pyrometry. A picturesque and almost romantic incident is connected with the work of J. J. Waterston, and it has been well described for us by Lord Rayleigh, who found a paper by Waterston in the archives of the Royal Society, in which he clearly enunciated, in pre-Maxwell days, the kinetic theory of gases. I have referred to Waterston because the fortunate circumstance of his having had, as he says, "to graduate a water thermometer,"[5] appears to have led him to the singularly advanced view that "the ultimate molecule, as an integral part of a gas or vapor, is capable of subdivision." "It is daily becoming manifest," he adds, "that the elementary molecule, though minute beyond conception, is to be studied as a microcosm essentially dynamical in its internal constitution, its apparently statistical condition being simply the antagonism of transcendent *vis viva* potents." He points to the fact that "the forces at the command of the chemist are insignificant in comparison to the heat and pressure with which the elements of matter have to contend in the body of the sun." Surely a very remarkable sentence, since justified, not only by Lockyer's work, but by the abandonment of iodine vapor in pyrometry which followed Victor Meyer's evidence as to its being dissociated at high temperatures.

(*To be continued.*)

## THE PREPARATION AND PROPERTIES OF FREE HYDROXYLAMINE.

A CONSIDERABLY improved method of isolating hyroxylamine is described by Prof. Bruhl, of Heidelberg, in the current *Berichte*, by which a tolerably large quantity of the pure substance may be prepared without danger in a short space of time, and which may therefore be of general interest on account of its suitability for lecture and demonstration purposes. It may be remembered that M. Lobry de Bruyn, who first isolated solid hydroxylamine two years ago (*vide Nature*, vol. xlv., p. 20), prepared it from a mixed solution of the hydrochloride and of sodium methylate in methyl alcohol. This solution, after removal of the precipitated common salt, was first concentrated over a water bath, under the diminished pressure of 100 mm., and afterward subjected to fractional distillation over a flame at the still lower pressure of 40 mm. A continuous fractionating vacuum apparatus was considered unsuitable, and the change of receivers could only be conveniently effected by temporarily arresting the distillation. This mode of operating frequently led to violent explosive decomposition of the heated hydroxylamine, and, moreover, the yield rarely exceeded 17 per cent. of the theoretical. Prof. Bruhl, desiring to obtain a considerable quantity of the pure base for spectrometric purposes, has been led to devise the following much more convenient method:

The methyl alcohol solution is first separated from the precipitated salt, and then immediately transferred to a slightly modified form of the well-known apparatus of Prof. Bruhl for fractional distillation *in vacuo*. This apparatus consists essentially of a distilling flask, provided with thermometer and entrance tube furnished with tap, a condenser, and a receiving arrangement which provides for the repeated and rapid change of receiver without impairing the vacuum and without arresting the distillation. This receiving arrangement consists of a short but wide cylinder of stout glass, into which the end of the condensing tube is introduced through a tubulus fitted with bored caoutchouc stopper. Inside the cylinder is a circular stand carrying six receiving tubes, which are capable of rotation by means of a rod passing, gastight, through a tubulus and its caoutchouc stopper in the top of the cylinder, and terminating in a handle outside. By suitable manipulation of the handle, each of the six receivers may be brought beneath the end of the condensing tube in turn while the distillation is proceeding. The distillation of the methyl alcohol solution contained in the distilling flask is effected by reducing the pressure to the lowest possible amount, and supplying the necessary heat by immersing the flask in a bath of hot water. On account of the explosive character of hydroxylamine, it is dangerous to employ even a small naked flame, which is liable to effect local superheating. The temperature of explosive decomposition lies in the neighborhood of 130°; by uninterrupted distillation in the manner indicated, and at a pressure not exceeding 22 mm., the hydroxlamine passes over entirely at a temperature of 56-57°, and by maintaining the water bath at only a few degrees superior to this temperature all danger of explosion is avoided. The methyl alcohol is practically entirely removed by the pump. Instead of leading the distillate through a warmed condenser, as recommended by M. de Bruyn, a practice which materially diminishes the yield by decomposition of a portion of the product, Prof. Bruhl finds it much more advantageous to feed the condenser with a constant supply of iced water; for although the melting point of hydroxylamine is 33°, it does not resolidify even at temperatures only a few degrees above zero, so that stoppage of the condensing tube does not occur. It solidifies instantly, however, in contact with a vessel immersed in ice and salt. The cylinder containing the receivers is therefore immersed in such a mixture, so that each drop of hydroxylamine solidifies the moment it enters the receiver. The hydroxylamine thus obtained in one operation is substantially pure. From 30 grammes of the hydrochloride about 10 grammes of the base may be obtained in one hour, a yield of 66 per cent. of the theoretical, which is four times that obtained by the method of M. de Bruyn. In the case of hydroxylamine becoming a commercial preparation, on account of its extraordinarily great antiseptic power, it would be quite easy, by introducing suitable additional condensers, to recover the whole of the methyl alcohol employed.

The pure white crystalline hydroxylamine melts according to the mode of heating and the size of the containing tube at 32-34°, and its boiling point for a pressure of 22 mm. is 56-57°. It may actually be cooled below 0° without solidifying, if allowed to remain at rest; but, like most other substances which exhibit the property of superfusion, it solidifies the moment it is agitated. In the solid state it does not appear to be liable to decomposition. Even in the liquid state at 0° indications of decomposition have not been observed. At 10°, however, bubbles commenced to form in the liquid, and at 20° a continuous evolution of gas, mainly nitrogen, occurs, becoming more and more violent as the temperature rises, until sudden explosion takes place. Hence in a warm summer hydroxylamine cannot be preserved in sealed glass tubes. Thus a specimen, after keeping for eight days in July, was found to be no longer capable of solidification even at − 6°, although there was sufficient of the base left undecomposed to explode with a certain amount of violence upon heating, less, however, than in the case of freshly prepared hydroxylamine. When just prepared one drop warmed in a test tube over a flame explodes with a report equal to that of a gun shot. It is suggested that hydroxylamine might be safely preserved in metallic vessels, for it appears likely that the notable action of the liquid upon glass causes the commencement of the decomposition.

At the temperature of 23·5° the relative density of pure liquid hydroxylamine is 1·2044. Its refractive index at the same temperature varies from 1·4375 for light of the wave length of the red lithium line to 1·4514 for light corresponding to the blue hydrogen line $H\gamma$. The substance thus exhibits a small refractive power and a surprisingly small dispersion. Indeed, its molecular dispersion is about the same as was found by Prof. Bruhl for nitrogen itself in triethylamine, so that the atom of oxygen and the three atoms of hydrogen would appear to exert no dispersive action, if the same value for nitrogen be assumed to be equally operative. The only possible explanation is that the nitrogen here united to oxygen and hydrogen possesses a lower spectrometric constant than when attached to carbon in triethylamine. From a systematic study of the spectrometric constants of the free base, and of the methyl derivative $CH_3NH.OH$ prepared by his assistant, Dr. Kjellin, an account of which was given in the Notes of *Nature* of November 9, Prof. Bruhl has been enabled to prove two important facts. The first is that the constitution of hydroxylamine can be none other than

$$\begin{matrix} H \\ H \end{matrix}\!\!>N-O-H.$$

The second is that the molecular refraction and dispersion of the nitrogen present in these compounds is the same as that of the nitrogen in ammonia gas, much lower than that of the nitrogen in triethylamine, and that the probable values of these constants of nitrogen linked in this manner, for sodium light, are respectively 2·495 and 0·072. This addition to our knowledge of the spectrometric constants of nitrogen will be of invaluable aid in unraveling the intricate subject of the constitution of the class of nitrogenous organic substances known as "oxims," a subject upon which Prof. Bruhl is now concentrating his attention.—*A. E. Tutton, in Nature.*

LAND AT TWOPENCE AN ACRE.—The lands owned in the Congo territory by the Belgian Congo Commercial and Industrial Company stand in the company's books at twopence per acre. Actual sales have been effected at this price, hence its adoption for account keeping purposes.

[1] "Comptes Rendus," vol. 1, 1835, p. 28. *Ibid.*, vol. 58, 1863, p. 49.

[2] "Comptes Rendus," vol. 90, 1880, p. 777.

[3] "Phil. Mag.," vol. 34, 1892, p. 1, and *ibid.*, p. 376.

[4] This couple was first used in 1873 by Tait. "Edinburgh Roy. Soc. Trans.," vol. 27, 1873, p. 125.

[5] See his paper, "Phil. Mag.," 1868, vol. xxvi., p. 116.



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